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President of New England Water Works Association,
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New England Water Works Association

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

MODERN PUMPS FOR SMALL WATER WORKS.

BY CREED W. FULTON.

In selecting this subject, the writer has been influenced by the desire to supplement to a certain extent the excellent paper of Mr. H. A. Symonds, covering " Engines for Small Water Works," read last December, and in doing so to present certain data which may prove of both interest and value to engineers, superintendents, and operators of small water works. It is hoped that this discussion may bring forth expressions of opinions from other sources which will be of interest and value to the members of this Association.

It has been somewhat difficult to arrive at a definition of small water works, but realizing the necessity of limiting the scope of the paper, it is assumed that a small water-works plant is one where the daily consumption does not exceed 3 000 000 gal.

Under ordinary conditions as commonly found in the average small pumping plant, this would represent a maximum brake horsepower of approximately 250 h.p. This figure is based on the assumption that a 3 000 000-gal. pump will operate against a maximum pressure of approximately 150 lb.

The types of pumps discussed, therefore, will be limited to those having a capacity of 3 000 000 gal. per twenty-four hours; that is, 2 100 gal. per minute, or less.

It should be borne in mind that any deductions or conclusions reached in this discussion are intended to apply to small plants only, and necessarily might have to be modified when considered in connection with large plants.

Earlier Types of Pumps.

Before entering into a detailed discussion regarding modern types of pumps for small water works, a brief summary touching the high points in the development of pumping machinery may prove of interest.

The first really modern and successful water-works pump was the direct-acting steam pump. It was nearly eighty years ago — 1840, to be exact — when Henry R. Worthington began his series of brilliant inventions which led to most of the modern forms of steam pumps.

One of the first steam water-works pumps was erected about 1854 for the city of Savannah. It was a compound machine of peculiar design as regards the arrangement of the high- and low-pressure cylinders, but it was a success and was followed by similar pumps for the city of Cambridge, Mass.

The year 1859 marked the introduction of the Duplex pump, which was for years the standard type of pumping engine. Various improvements followed as a result of the efforts of such men as Blake, Knowles, Cameron, Marsh, Dean, and others.

The use of steam pumps on a large scale began about the year 1860. Shortly after this, the Cornish engine made its entry, followed by several other vertical pumping engines of various designs.

The crank and fly-wheel pump appeared about 1868. Various other improvements followed shortly, these being principally improvements in the detail of mechanism. No really fundamental changes in design occurred until about 1876, when the Corliss pumping engine made its first appearance and proved to be a great success.

Steam was now being used expansively with a marked increase in economy. Duties, by this time, had risen from around 50 000 000 ft.-lb. per 100 lbs. of coal, to around 120 000 000 ft.-lb. per 100 lb. of coal.

The Holly Manufacturing Company followed up the Corliss invention with a special water-works pump which proved very successful, and which has, with certain modifications, been used ever since. Numerous other makes and types made their appearance, and the steam pump continued in use with increasing force up to within the last fifteen or twenty years.

It was quite logical that the steam pump should enjoy this period of intensive development and use. By so doing, it was following, step by step, the development of the steam engine — then the chief prime mover or source of power. It should be kept in mind at this point that the development of pumps has always been directly and greatly influenced by power-plant development, and just as the original steam pump followed the development and improvements in the steam engine, so the present-day pumps are the outgrowth of new tendencies in power-plant development.

Recent Tendencies.

Within the past fifteen or twenty years, new tendencies, however, have asserted themselves, resulting in a marked change in power-plant development.

The isolated power plant has given way rapidly, and very generally, to the central station. The development of the steam turbine and improvements in the design of electrical machinery have made possible and successful central stations of enormous capacity, with transmission systems of almost unlimited scope.

As a result, we have witnessed the gradual electrification of factories, trolley lines, railroads, and, of particular interest to this meeting, water works.

This change has been forced by basic economic factors, the chief one being the economies made possible by the consolidation of a large number of small steam plants into one large central station. The reasons for, and the results of, this consolidation are familiar to almost every one to-day.

Students and observers of power developments generally agree that the future will witness the continued consolidation of power plants — that even larger central stations will be the rule, with marked accompanying development in transmission systems linked together and covering the entire country.

How has this power-plant development affected water-works plants? One thing is certain, and that is, it has affected and will continue to affect chiefly the smaller plants. The larger water works were the first to utilize the steam pump, and they will undoubtedly continue to use them to good advantage for years to come; but it is obvious that the direct-acting steam pump is passing away as far as its use in small plants is concerned. Not only is the fuel or power cost too high, but such an installation in a small plant involves the problem of a licensed engineer and certain other unfavorable factors which mitigate against its use in these modern days.

This statement should not be interpreted as meaning that steam pumps of any kind are not to be considered in small plants. The crank and fly-wheel pump, the turbine-driven centrifugal pump, and the recently developed Una flow, steam pumpimg engine will under certain conditions prove acceptable units. In the main, however, for pumps of less than 3 000 000-gal. capacity, the tendency is to get away from steam as the driving power.

One reason for this is that the first cost of such installations is often so high that the fixed charges offset the difference in economy, in addition to which the labor requirements are usually rather severe.

Only under peculiarly favorable conditions could a steam-driven plant compete with a modern plant equipped with electrically driven or internal-combustion engine driven pumps for capacities of 3 000 000 gal. or less. *

There are, of course, many instances in small plants where modern pumps are driven from steam engines, steam turbines, water wheels, etc., but such instances usually occur in old plants where the physical condition of the pumps makes replacement necessary; but for one reason or another the old source of power has to be retained in its original, or at best, a slightly modified form.

This tendency to get away from steam pumps in small plants has been accentuated by the development and perfection of the internal combustion engine. The highly perfected Diesel or semi-Diesel type of oil engine is admirably adapted for driving reciprocating pumps where high duties are desired. This combination of pump and engine has been used very suc-

cessfully in a large number of plants ranging in capacities from one million to four or five million gallons per day.

The perfection of the gas producer and gas engine has likewise made it possible to successfully use a combination of gas producer, gas engine, and reciprocating or centrifugal pump to good advantage. The development of the modified Diesel, commonly known as "semi-Diesel" engine has provided a moderately priced yet comparatively high-duty internal-combustion engine which is very attractive, particularly in small plants.

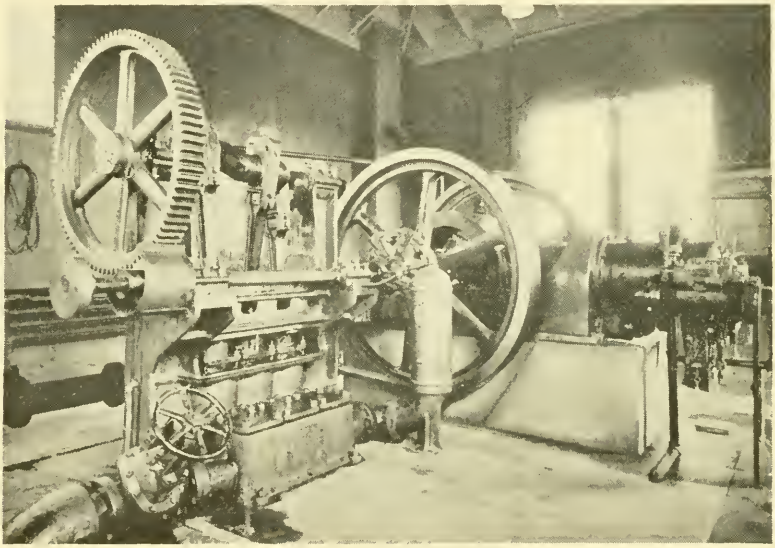


Fig. 1. Vertical Single-Acting Triplex Plunger Pump Direct Connected to De La Vergne Oil Engine. Waterworks, Town of Shrewsbury, Mass.

A combined unit of this type is very desirable for small water works. It combines simplicity, compactness, and high economy, with complete reliability. As no power is required from outside sources, the engine and pump being a complete power plant in themselves, there is no danger from possible shut-downs such as is sometimes the case where electric lines have to be carried a great distance from the source of supply to the pumping station. The pump illustrated above is an 8 x 10 in. triplex plunger pump with a capacity of 300 gal. per minute against 150 lb. discharge pressure. The pump is connected to a 35 h.p. De La Vergne oil engine.

The latest and most apparent tendency in small water-works plants is the use of pumps deriving their power from independent or outside sources. There are to-day two types of power units especially applicable to modern pumps for small water works. They are: (*a*) The electric motor and (*b*) the internal combustion engine. Under the latter heading we may class the gas engine, using either natural, illuminating, or producer gas, and the fuel oil or distillate engine.

It is not the intention of this paper to discuss in detail the design and construction of engines or power units for driving modern pumps. This

matter is covered in excellent shape by the paper presented by Mr. H. A. Symonds at the meeting of this Association on the 12th of December, 1918. The discussion will, therefore, cover primarily the types of modern pumps, general features of design and construction, adaptability to various conditions, relative economy, and the proper selection, installation, and operation of the same.

Modern Pumps.

The modern pump for small water works will ordinarily be one of two general types: (*a*) reciprocating, or (*b*) centrifugal.

The name "reciprocating pump" covers all pumps in which the water is displaced either by a plunger, piston, or bucket, working back and forth in a cylinder.

Reciprocating pumps are generally classified in several ways:

(*a*) In regard to the plane in which the plungers or pistons move (vertical or horizontal).

(*b*) In regard to the number of displacements (single acting or double acting).

(*c*) In regard to the number of cylinders.

(*d*) In regard to the manner of packing.

(*e*) In regard to the form or kind of displacer (plungers or pistons).

For example, a type of reciprocating pump common to small water works is the vertical single-acting, triplex, outside-packed plunger pump. (See Fig. 1.) Another familiar type of reciprocating pump is the vertical double-acting, triplex piston pump. (See Fig. 2.) It is not customary to refer to the way this latter type is packed, as piston pumps are essentially inside-packed pumps.

In the horizontal type of reciprocating pump the pump may be of the single- or double-acting plunger type, either outside center packed, or outside end packed. (See Fig. 3.) This horizontal type of machine is most apt to be used for larger capacities or heavier duty.

Characteristics of Reciprocating Pumps.

The reciprocating pump has characteristics which are commonly known to every one on account of the length of time that pumps of this kind have been in use.

A reciprocating pump is known as a positive displacement pump for the reason that the water that is discharged from the pump is actually displaced by a plunger, piston, or bucket. It is obvious, therefore, that for any given size of reciprocating pump the capacity of the pump depends on the speed at which it is run. Capacity is, therefore, directly proportional to the speed in any reciprocating pump. This is theoretically true, and almost practically true, the only modification of this rule being caused by a

slight difference in the slip of a pump through the valves, depending upon the speed and suction lift. Usually the slip is greater as the speed and suction lift become greater.

A reciprocating pump will operate against any head from zero head up to the maximum head for which the pump is designed, and will deliver any capacity within the range of the pump by simply selecting the proper speed to give the capacity. In other words, the head which the pump develops is not a function of the speed, as is the case in a centrifugal pump.

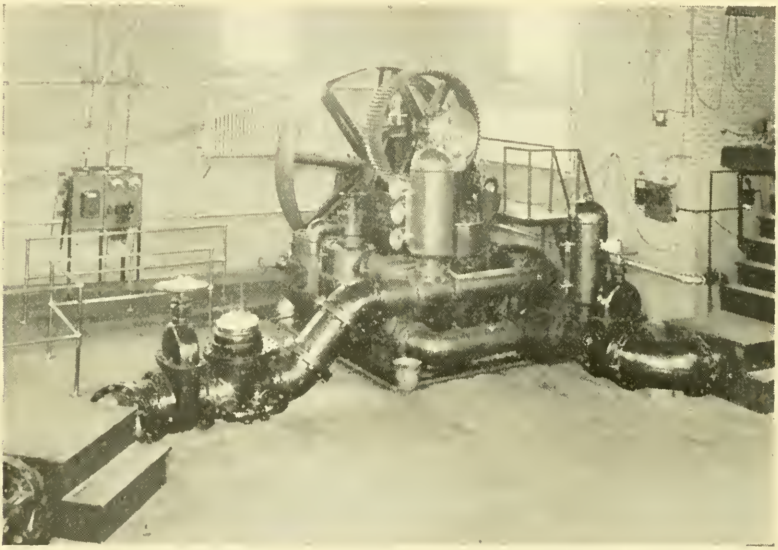


FIG. 2. VERTICAL DOUBLE-ACTING TRIPLEX PISTON PUMP. WATER WORKS, TOWN OF NORWOOD, MASS.

This type of pump is in large use in small water works. The particular unit shown above is belt driven from a 200 h.p. motor. The pump has a capacity of 2 000 000 gal. of water in twenty-four hours against a total net head of 350 ft. Pump of this type will show an efficiency of from 85 per cent. to 90 per cent. under the operating conditions specified. This makes a thoroughly reliable unit for hard, steady service.

The power consumed by a reciprocating pump is directly proportional to the product of the capacity in gallons per minute, and the head in feet. A rule commonly used by those having to do with pumps is to figure the horsepower by the following formula:

h.p. = capacity in gallons per minute $\times$ total head in feet, $\div$ 3 960.

For the sake of simplicity most pump men use 4 000 as a divisor instead of 3 960. For example, the theoretical horsepower required by a pump delivering 500 gal. per minute against 200 ft. head would be $500 \times 200 \div 4\,000 = 25$ h.p.

In order to obtain the actual brake horsepower required to drive the pump, the theoretical horsepower is divided by the efficiency of the pump.

For example, the ordinary reciprocating pump will have an efficiency somewhere between 65 per cent. and 88 per cent. Assuming, therefore, a pump for the capacity and head outlined above, under which conditions the theoretical horsepower would be 25, and assuming that this pump had an efficiency of 80 per cent., then the brake horsepower required to operate the pump would be $25 \div .80 = 31.3$ brake horsepower.

The efficiency of any reciprocating pump varies, depending on the speed and head against which the pump operates. For example, suppose a pump designed for a normal capacity of 1 000 gal. per minute against a total net head of 300 ft. is being operated at its normal rating, — that is,

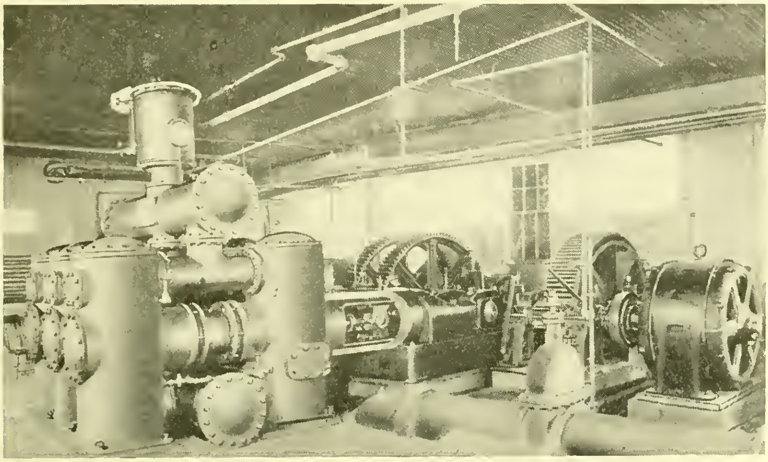


Fig. 3. Horizontal Double-Acting Center-Packed Plunger Pump. Waterworks, City of Cohoes, N. Y.

The particular unit illustrated above is interesting as it shows a possible arrangement for direct connection both to a motor and to a water wheel. This pump is arranged for operating from both sources of power. Pump has a capacity of about 3 000 000 gal. in twenty-four hours against 100 lb. discharge pressure. Pumps of this type give extremely good efficiency when operating at full load; efficiency being around 85 per cent. to 90 per cent. for the conditions specified above.

100 per cent. rating. Under these conditions, a pump of this kind would ordinarily have an efficiency of around 85 per cent.

Now, if this pump should be slowed down and run at a capacity of only 750 gal. per minute against the same head, the efficiency would drop off. There is no exact rule which can be used to figure the variation in the efficiency under such conditions. The efficiency curves (Fig. 4), as shown herewith, illustrate the general shape of the efficiency curve and the effect which variation in capacity, speed, or head will have on any reciprocating pump. Generally speaking, the efficiency is greatest when the pump is operated at 100 per cent. rating or slightly more. If the head or capacity, either, is decreased below 100 per cent., the efficiency will fall off, following, generally, the course outlined by the efficiency curves which are herewith shown.

Centrifugal Pumps.

The centrifugal pump of to-day is a development of the last twenty years. Although 1680 is the year given when the first centrifugal pump was built, and 1818 the year when the first crude pump of this type (called the

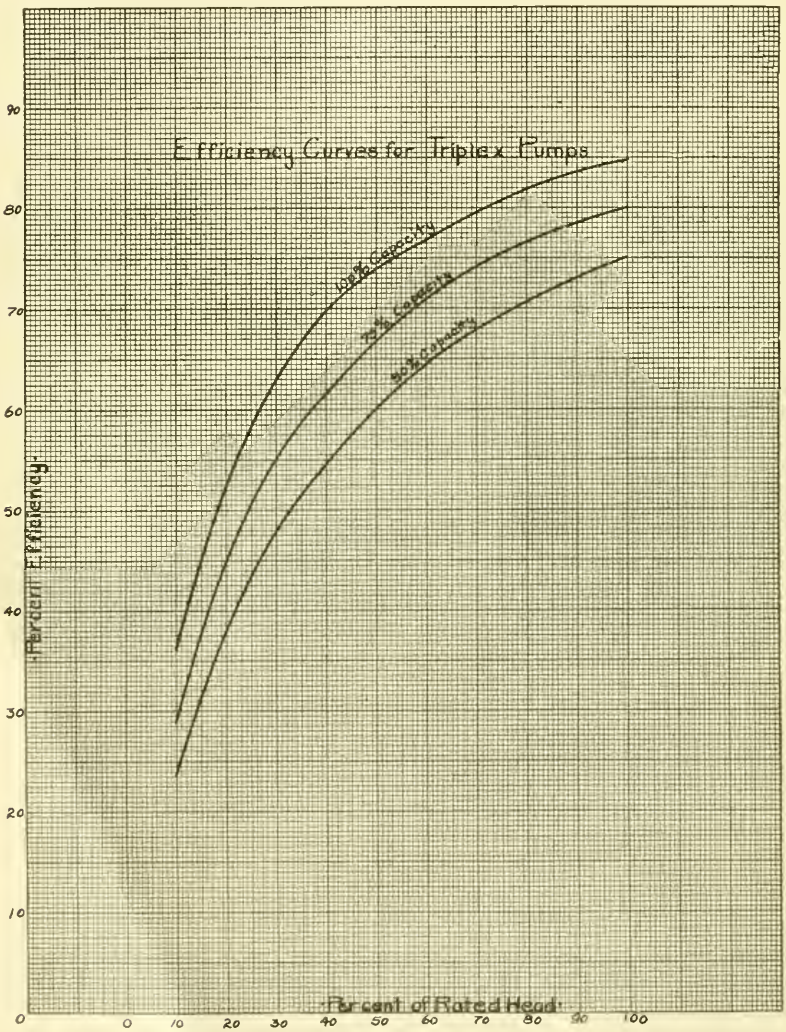


Fig. 4.

"Massachusetts pump") was built in this country, it was not until recent years that this type of machine was considered seriously. It was due probably to the fact that a centrifugal pump is a relatively high-speed machine, and there was no motive power well suited to it.

With the introduction of the electric motor and steam turbine, con-

ditions have changed. These high-speed machines stimulated the development of the centrifugal pump, and we now find an ever-increasing demand for this type of pumping machinery.

Pumps that depend for their action upon centrifugal force or the variation of pressure due to rotation, are termed "centrifugal pumps." Other factors, however, have an important effect, as will be shown later.

Classification of Centrifugal Pumps.

Centrifugal pumps may be divided generally into two classes: (*a*) volute pumps, (*b*) turbine pumps.

A volute pump is one in which there are no diffusion or guide vanes, but instead the casing is spiral in shape. The casing may be considered as a great guide vane.

The effect of this spiral, sometimes called "volute," is the production of an equal velocity of flow at all sections around the circumference of the casing, and the velocity of the water, as it leaves the impeller, is gradually converted into pressure as it flows to the discharge pipe.

A turbine pump is one in which the impeller is surrounded by a circular plate or diffuser which contains ribs forming water passages, sometimes called "guide vanes." These vanes are so shaped that they provide gradually enlarging passages which change the velocity of the water leaving the impeller, thereby reducing the velocity head into pressure head.

Centrifugal pumps are also classified as horizontal or vertical, depending on whether the shaft operates in a horizontal or vertical position. The ordinary water-works pump is of the horizontal type.

These pumps are further referred to as "single suction" or "double suction," depending on the type of impeller which is used; that is, whether the impeller takes the suction from one side only, in which case it is single suction, or whether the impeller takes the water from both sides, in which case it is a double suction impeller.

The pump is also referred to at times by the name of "open impeller" or "enclosed impeller," but this, in classification, is of minor importance. However, enclosed impeller pumps usually develop higher efficiencies and are generally used for water-works service. (See Fig. 5.)

Theory of Centrifugal Pumps.

The theory or action of a centrifugal pump may be well illustrated by the old simile of the "boy and bucket." The boy whirls the pail of water about his head, and not a drop is spilled provided the pail is moving fast enough. The force that holds the water against the bottom of the pail is called "centrifugal force."

Now, suppose that a hole is punched in the bottom of the pail. A stream will issue forth. The stream would be continuous if the boy's arm was a pipe supplying water to the pail.

The boy's arm is a suction pipe; the pail is the impeller throwing a stream. The casing of the pump has been introduced to guide the stream in one particular direction to the discharge outlet.

Crudely, this is the story of the centrifugal pump. A word about the general principle on which centrifugal pumps work may be of interest.

Suppose there is a body — say, a pail of water on top of a house 120 ft. from the ground. Suppose it is suddenly pushed off — it would fall to the ground with an increasing speed, and it would finally strike the earth when moving at a certain rate of speed or velocity. Let us say that it

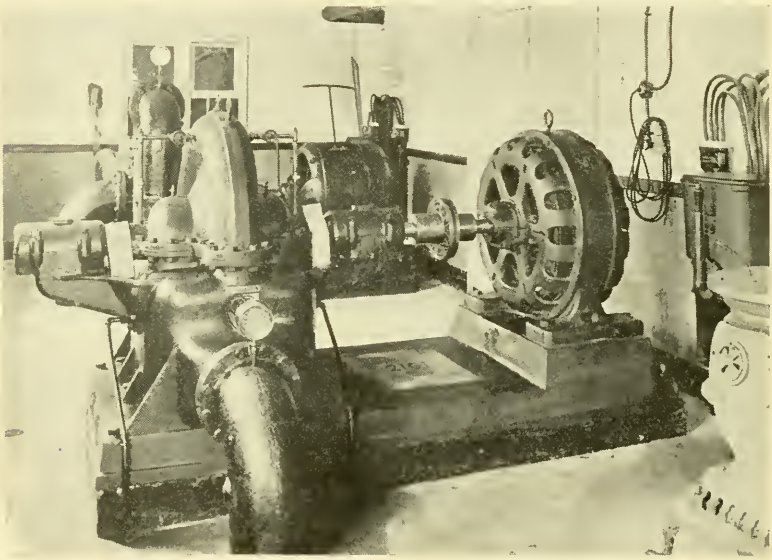


FIG. 5. HORIZONTAL SINGLE-STAGE DOUBLE-SUCTION VOLUTE CENTRIFUGAL PUMP, DIRECT CONNECTED TO AN ELECTRIC MOTOR. CONSOLIDATED WATERWORKS COMPANY, UTICA, N. Y.

This type of unit can be very satisfactorily used in small water-works plants for heads up to about 150 ft. A unit of this kind combines small floor space requirements, low first cost, with simplicity of operation and thorough reliability. The operating efficiency of units of this type is somewhat lower than that of the reciprocating pumps, but this disadvantage is frequently offset by the advantages just mentioned. A pump of this particular type can be operated with as little attention as any type of pump in small plants.

was moving 5 265 ft. per minute when it struck. Now, suppose we wish to throw this pail of water from the ground to its original position on top of the house. In order that it reach this elevation, we have to start it with an initial velocity or speed the same that it had when it struck the ground in its fall, — i. e., 5 265 ft. per minute. The formula for this law which gives the velocity of a falling body is as follows: $V^2 = 2\,gh$, in which

V = velocity of the moving body in feet per second;

g = the force or attraction of gravity = 32.2 ft. per second;

h = head in feet, or distance through which it falls.

Substituting the values used, in the above example in this formula, we find that the velocity that we have assumed, of the falling pail, was correct.

$V^2 = 2 \times 32.2 \times 120 = 7\ 728.$

$V\ = 87.9$ ft. per second.

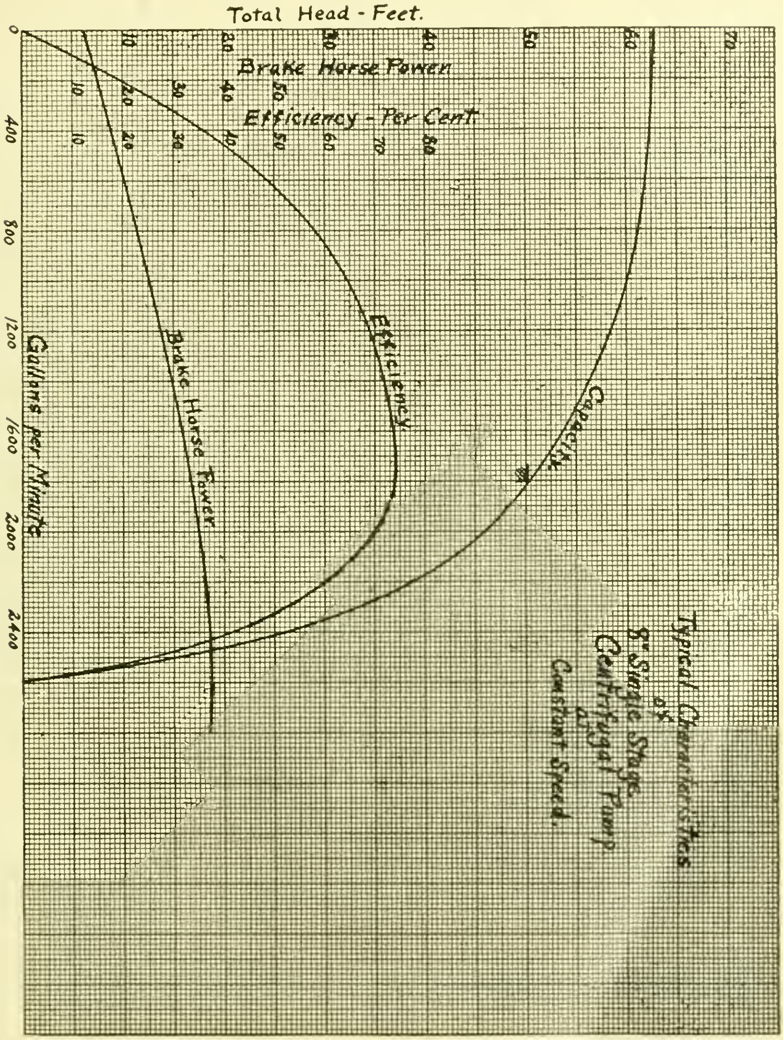


Fig. 6.

Then, as there are sixty seconds in one minute, $87.9 \times 60 = 5\ 265$ ft. per minute.

It is this law or formula that is used in determining the speed of the impeller in the pump. The water, as it leaves the impeller to be thrown to

a certain height, must have the same velocity as it would if it fell from that height as just shown.

From the formula just stated it is seen that the head generated by a centrifugal pump is proportional to the square of the velocity imparted to the water at the periphery of the impeller. Generally speaking, the peripheral velocity of the impeller is equal to the velocity corresponding to the head against which the pump is to operate multiplied by a certain constant which varies according to the conditions and the ideas of the designer, but which is usually somewhat more than unity.

In other words, it can be said that the head which any centrifugal pump will generate is directly proportional to the peripheral speed of the impeller. As the peripheral speed of any impeller is a function of the speed, that is, the revolutions per minute, it is evident therefore that the head which the pump will generate must vary as the square of the speed.

In any particular centrifugal pump, supposing the impeller remains unchanged, the following characteristics will obtain:

1. The head will vary as the speed squared.
2. The quantity will vary directly as the speed.
3. The horsepower will vary as the cube of the speed.

In order to develop the theory from which these general rules are derived it would be necessary to go into an almost endless amount of figures. The three rules as stated are the fundamental rules governing the characteristics of any centrifugal pump. By referring to the characteristic curves illustrated by Fig. 6, the variation in capacity, head, horsepower, and efficiency will be clearly seen. This cut shows what are generally known as the characteristic curves of a centrifugal pump. The curve marked " capacity " shows the variation in capacity of any pump running at constant speed when operated against varying heads. The shape of this head capacity curve is generally about the same as shown.

By referring to the efficiency curve, it will be noted that the efficiency rises very rapidly from the point of no delivery, or shut-off, reaching its maximum at about the normal rated point of the pump, and falling off rather rapidly just before and at the point of maximum delivery or no head.

It may be said that the general shape of characteristic curves can be varied by variations in the design of the impeller. In other words, where it is necessary a steep characteristic curve can be produced; or, if required, a comparatively flat characteristic curve can be produced. The characteristic curve shown here is about the average for pumps working under conditions such as would be found in the average water-works plant.

The general theory which has been outlined and the characteristics as shown by the curves just referred to hold for all types of centrifugal pumps. The theory for any centrifugal pump is fundamentally unvaried. The actual shape of the characteristic curves, however, may be varied within certain limits to suit conditions. For practical reasons, however,

the head which can be generated by a single impeller is limited, and when the actual head against which a centrifugal pump must operate exceeds the practical limit of a single-stage pump, then it is necessary to use two or more stages.

It may be said that for the ordinary forms of drive, such as electric-motor drive, a single-stage pump will not ordinarily be good for more than around 200 ft. per stage. This figure is subject to variation, however, depending on conditions. For the average small water-works plant, where the pressure ranges from 100 to 150 lb., a two-stage pump is generally used.

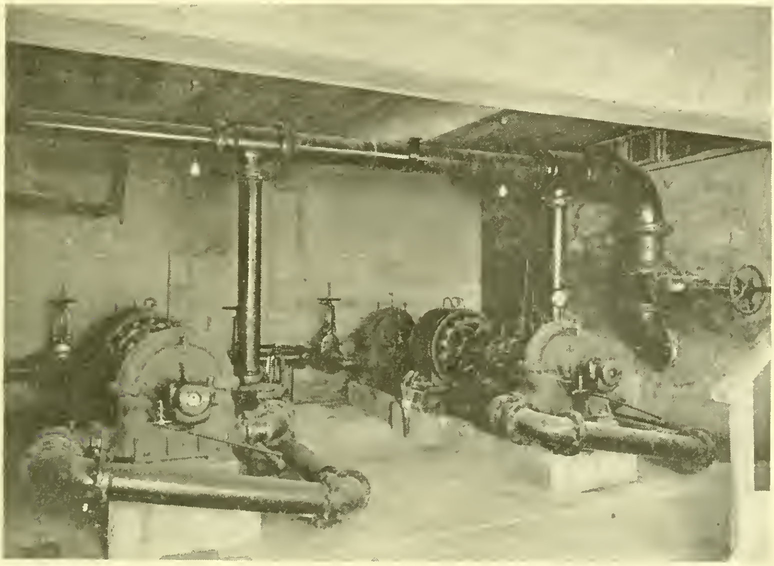


Fig. 7. Centrifugal Pumps Direct Connected to Electric Motors. City of Charles City, Iowa.

The units illustrated in the above photograph are interesting as they show the possibilities of centrifugal pumps arranged for operation under two entirely different sets of conditions. The pumps illustrated above are each 4-in. single-suction volute pumps having a normal capacity of 500 gal. per minute each against a total net head of 135 ft. each. For domestic service the pumps are operated in parallel, each unit delivering 1 000 gal. per minute against a total net head of 135 ft. In case of fire, the units are so arranged that the two pumps on each unit will operate in series, thereby enabling each unit to deliver 500 gal. per minute against a total net head of 270 ft. Both complete units are exactly alike, one being used as a spare in case of emergency.

Operation of Centrifugal Pumps.

In order to illustrate the operation of the centrifugal pump it must be assumed that the suction pipe and pump casing are completely filled with water. When the pump is started up and reaches the proper speed, the centrifugal force generated by the impeller will throw the water contained in the impeller outward into the casing, and it will flow around the volute and out the discharge opening of the pump. This process of throwing out

the water in the impeller tends to create a vacuum in the impeller, which results in the water in the suction line rising and filling the impeller. This process goes on continuously until the pump is stopped or unless the vacuum is broken by the admission of air on the suction side of the pump.

Comparative Pumping Costs.

When the question of building a new pumping station or of making changes in the pumping equipment of an old station is under consideration, those having to do with the problem are naturally interested in determining which type of pump is best suited for their particular requirements.

No set of rules can be laid down from which interested parties could make a selection and be sure that they were making the best selection for their requirements. Such a wide variation in conditions has to be met that the formulation of any rules would be almost impossible.

The question of the proper type of pump is therefore one to be decided in each particular case after carefully considering all of the conditions which have to be met in that particular case.

Without attempting to lay down any hard-and-fast rules, certain observations with regard to this matter may be made which possibly would be of interest and of some use to those contemplating a new station or changes in their old pumping station.

In a small modern plant the choice of pumps would usually lie between a suitable reciprocating pump and a suitable centrifugal pump for the conditions to be met. In every case one fact is apparent, and that is that the first cost of a centrifugal pump for the same duty is always less than the first cost of a reciprocating pump. In fact, the first cost of a centrifugal pump is often as low as one quarter the cost of a triplex, and seldom runs over one half the cost of the triplex pump.

This general observation is of interest because of the fact that in figuring comparative pumping costs it is not the first cost alone which counts, but the yearly cost of operation, and in order to arrive at the yearly cost of operation the first cost of equipment is of interest and value because it determines to a large extent the fixed charges which have to be included as a part of the yearly cost of operation.

It is therefore well to keep in mind that in any installation the fixed charges will be less when centrifugal pumps are used, due to the lower first cost of such units.

Another general rule which should be borne in mind is that the operating efficiency of triplex, or reciprocating, pumps is in a large majority of cases higher than the efficiency of centrifugal pumps. This condition of affairs tends to balance the lower first cost with the resultant lower fixed charges on the centrifugal units.

The question of determining the proper type, therefore, is largely a question of balancing the saving in fixed charges due to the lower first cost

of centrifugal units against the saving in operating costs due to the higher efficiency of the reciprocating unit.

In the case of a new station, it may be well to remark that not only should the first costs of pumping machinery be compared for the purpose of arriving at comparative fixed charges, but the question of the first cost of the building itself is of considerable importance. Generally speaking, reciprocating pumps require more floor space, therefore larger buildings, and they require heavier foundations, all of which adds to the first cost of the building and therefore increases the investment, and consequently in stations of this type the yearly fixed charges are bound to be higher. The point to be kept in mind is that a comparison of yearly operating costs should properly include in new stations the investment both on the building and on the pumping equipment.

There frequently are cases where the increased cost of power for driving a centrifugal pump is more than offset by the decrease in fixed charges due to the lower first cost of the machine itself and further to the lower first cost of the building.

In figuring fixed charges the rate of interest and depreciation, as well as insurance, taxes, etc., are somewhat variable and must be decided according to local conditions.

From the standpoint of cost of power for operating different types of units, the accompanying chart of comparative power costs will prove of interest. This chart gives a fairly accurate idea of the cost per horsepower hour for various types of prime movers.

In addition to fixed charges resulting from investment both on buildings and machinery and the cost of power to operate the units, there is the item of labor, which must be considered in comparing the cost of operation of the different types of units.

The item of labor, while at times hard to definitely determine, is an important part of the total yearly pumping costs in most small plants. In fact, in many small plants the item of labor will frequently be found to be the largest single item of expense. In several instances which have been noted, almost the total elimination of labor charges has been made possible by using the proper type of unit. In such cases the particular unit used, if judged alone by the yearly cost of power for operating, would be considered uneconomical, but the fact that it eliminated almost entirely the labor charge made it the better unit for the conditions to be met.

The electrically-driven centrifugal pump, for example, is admirably adapted for eliminating a very considerable part of the usual attendance and labor charges. The cost of electric power for driving this type of uint, is, however, from 10 per cent to 30 per cent. higher than the cost of electric power for driving the average triplex reciprocating pump.

As a general rule, there is less danger attendant on operating a centrifugal pump without constant supervision than there is in operating a triplex pump. This is due to the nature of the design and construction of the units.

Comparative Power Costs.

Type of Engine.	Fuel.	Cost of Fuel.	Consumption per B.H.P. per Hour.	Cost per B.H.P. per Hour.	Cost 100 H.P. 10 Hours	Cost 100 H.P. per Year 3 000 Hours	Yearly Cost per H.P.
* Gas engine on producer gas.	No. 1 Buckwheat	$6.00 per ton	1 lb.	$0.003	$3.00	$900.00	$9.00
	Anthracite pea coal	.... 8.00 per ton	1 lb. $1\frac{1}{4}$ lb.	.004 .005	4.00 5.00	1 200.00 1 500.00	12.00 15.00
	Natural gas	.40 per M	10 cu. ft. at 1 080 Btu.	.004 .005	4.00 5.00	1 200.00 1 500.00	12.00 15.00
Diesel engine...............	Fuel oil	.07 per gal. .10 per gal.	1/15 gal.	.0047 .0067	4.70 6.67	1 410.00 2 000.00	14.10 20.00
Semi-Diesel engine	Fuel oil	.07 per gal.	1/10 gal.	.0077	7.70	2 310.00	23.00
Steam turbine condensing....	Bituminous coal	6.00 per ton	3 lb. 4 lb.	.009 .012	9.00 12.00	2 700.00 3 600.00	27.00 36.00
Compound condensing steam engine	Bituminous coal	6.00 per ton	4 lb.	.012	12.00	3 600.00	36.00
Electric power..............	....	.03 per kw. hr. .02 per kw. hr.	....	.0225 .015	22.50 15.00	6 750.00 4 500.00	67.50 45.00
Kerosene engine............	Kerosene	.12 per gal.	$\frac{1}{8}$ gal.	.015	15.00	4 500.00	45.00
Steam boiler coil fired.......	Fuel oil	.07 per gal. .10 per gal.	$\frac{1}{4}$ gal. $\frac{1}{4}$ gal.	.0175 .025	17.50 25.00	5 250.00 7 500.00	52.50 75.00
Simple non-condensing steam engine	Bituminous coal	6.00 per ton	8 lb.	.024	24.00	7 200.00	75.00
Gasoline engine.............	Gasoline	.26 per gal.	$\frac{1}{8}$ gal.	.0325	32.50	9 750.00	97.50

*Courtesy Nelson Blower Co.

In view of the importance of the labor item in most small plants and the possibility of largely or totally eliminating this labor charge by the proper selection of a unit, it is well to carefully consider in every case the probable labor cost and the possibility of saving on this item.

Regardless of which type of unit is selected, there is always a certain amount of maintenance required in connection with every unit, and therefore the maintenance costs on various types is of interest as a part of the yearly cost of operation.

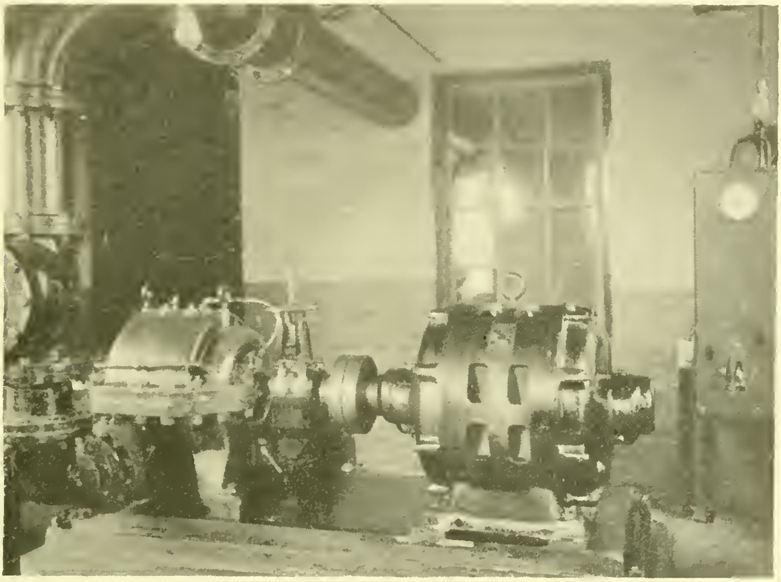


FIG. 8. MULTI-STAGE TURBINE CENTRIFUGAL PUMP DIRECT CONNECTED TO MOTOR. PUTNAM WATER WORKS, PUTNAM, CONN.

This illustrates well the modern type of multi-stage pump for direct connection to motor. Pumps of this type can be designed for pressures up to 300 lb. per sq. in. Units are simple, require small amount of floor space, are thoroughly reliable, and would show a low yearly cost of operation. They are well adapted for elimination of labor charges; as the only attendance required is a daily inspection of the unit, continued supervision is unnecessary.

The maintenance charges on modern pumps should be a comparatively small part of the total yearly cost of operation provided the pump and driving unit are not seriously overloaded and are given first-class attention. The item of maintenance, however, is often quite variable, and unless the proper machine is selected the item of maintenance sometimes becomes a serious matter. Prospective users of pumps would do well in every case to inspect the possible cost of up-keep before considering their estimate for the yearly cost of operation accurate or complete.

Summarizing briefly, therefore, the question of total yearly cost of operation, it may be said that in making up a comparison on two different types of units the following items should always be carefully considered:

1. Fixed charges.
2. Cost of power (or fuel.)
3. Labor cost.
4. Maintenance.

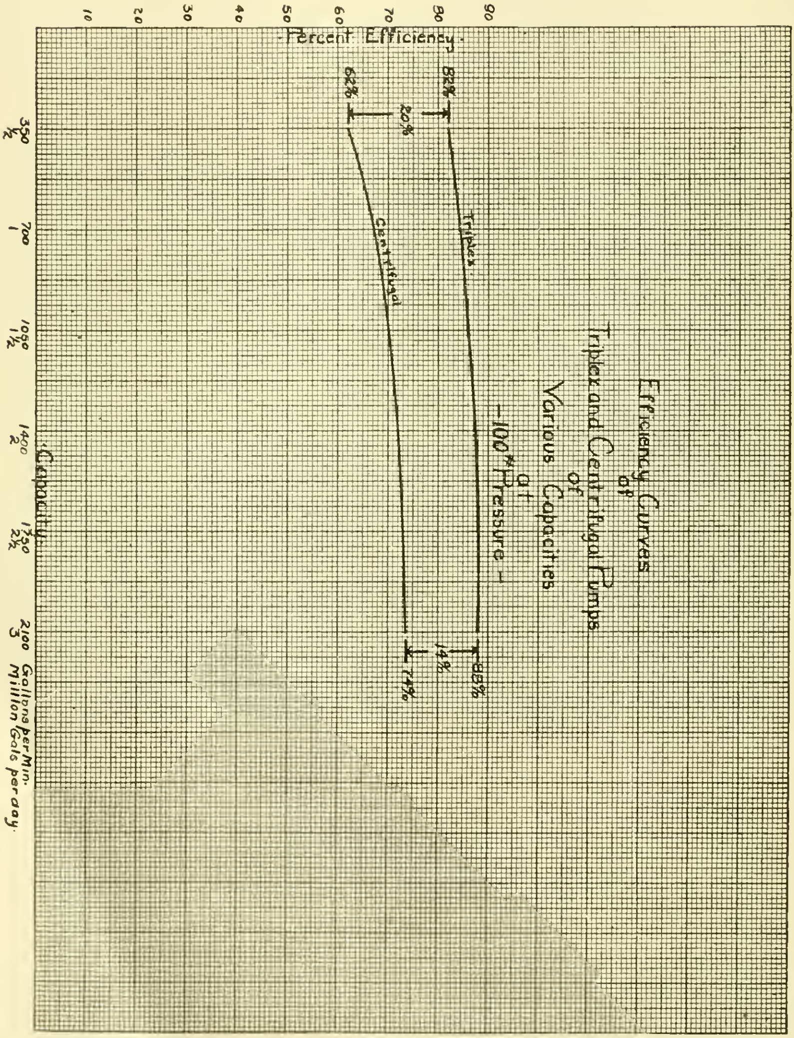


Fig. 9.

It would be impracticable here to enter into a detailed discussion of first cost of various types of pumping units. Prices for water-works pumping equipment are usually furnished on application only, and are not standard, unless perchance standard stock equipment can be used. Prices for estimating or purchasing purposes can quickly be obtained from the

various manufacturers, and fixed charges can be readily computed from them. Likewise operating efficiencies and resultant costs of power can be obtained for any particular or special conditions, from which the yearly cost of power can be readily computed.

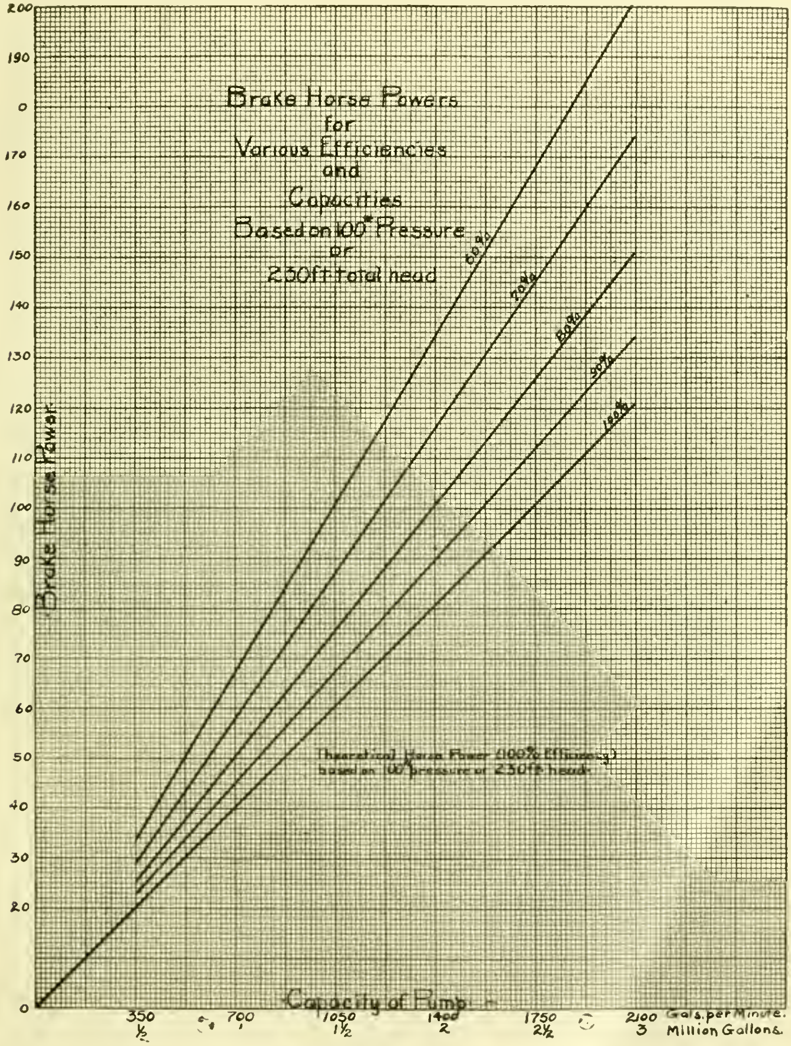


FIG. 10.

In order, however, to give some idea as to the cost of power for operating various types of units, the accompanying curves have been prepared.

Fig. 9 gives a comparison of the efficiency of modern triplex pumps as compared to the modern centrifugal pump. The horizontal scale represents capacity either in millions of gallons per twenty-four hours or in

gallons per minute. It is assumed that the average pump will operate at approximately 100 lb. pressure, and the comparative efficiencies given are based on this assumption. However, the efficiencies would not vary greatly between 100 and 125 lb. operating pressure.

By reading up from the capacity scale to the efficiency line for the proper type of pump and then reading horizontally to the left, the normal operating efficiency which may be expected for that particular capacity will be found.

For example, a centrifugal pump having a capacity of 2 000 000 gal. per day, or approximately 1 400 gal. per minute, would have an efficiency of 72 per cent. approximately; whereas a triplex pump for the same conditions would have an efficiency of approximately 87 per cent.

By using the efficiencies given, the actual horsepower required to operate each type of pump can be readily computed.

For the sake of convenience, however, Fig. 10 has been prepared. By referring to this curve sheet, reading up from the capacity just given, namely, 2 000 000 gal. per day, or 1 400 gal. per minute, to the efficiency line of the centrifugal pump, namely, 72 per cent., and then horizontally across to the B.H.P. scale at the left, it will be found that a centrifugal pump with an efficiency of 72 per cent. will require approximately 113 B.H.P. to operate against 100 lb. pressure. Similarly, a triplex pump for the same capacity with an efficiency of 88 per cent. would require approximately 92 B.H.P. to operate. The saving in power, therefore, in favor of the triplex, is 113 minus 92, or 11 B.H.P., which figure for estimating purposes might safely be used in figuring the yearly cost of power.

Having figured the proper brake horsepower, the approximate cost per horsepower hour can be ascertained by referring back to the chart covering comparative power costs, — previously shown on page 16, assuming, of course, the cost of fuel or current is known.

For example, suppose a certain triplex pump requires 100 B.H.P. to operate, as figured from the horsepower curves Fig. 10. Now, assuming a Diesel engine is to be used, with fuel oil costing 10 cents per gallon, from the comparative power costs chart we see that the yearly cost per horsepower is \$20. Therefore the fuel or power cost for a year (3 000) for 100 h.p. will be 100 × \$20 = \$2 000. Similarly, the cost of electricity at \$0.02 per hr. would be \$45 per horsepower per year, or a total cost of \$4 500 per year for power.

This general method of comparing the yearly costs of operation will apply to almost any plant. In certain cases it is rather difficult, however, to follow the general methods just enumerated in reaching a decision as to which type of pump should be used. This is particularly true in the case of old plants where the old pumping machinery has become obsolete or worn out, and it is simply desired to substitute new pumps for the old. In such cases the item of investment on the building is eliminated, as the building and various other parts of the old equipment usually are retained.

In such cases the question of selection depends almost entirely on the comparative first costs of the pumps only, the comparative yearly cost of power, and the possibility of saving on the labor charges.

A thorough, accurate knowledge of existing operating conditions is one of the essential requirements in selecting pumps. In fact, this is the first requirement, and should precede all efforts to compare the yearly cost of operation as just outlined. Inadequate knowledge as to the true

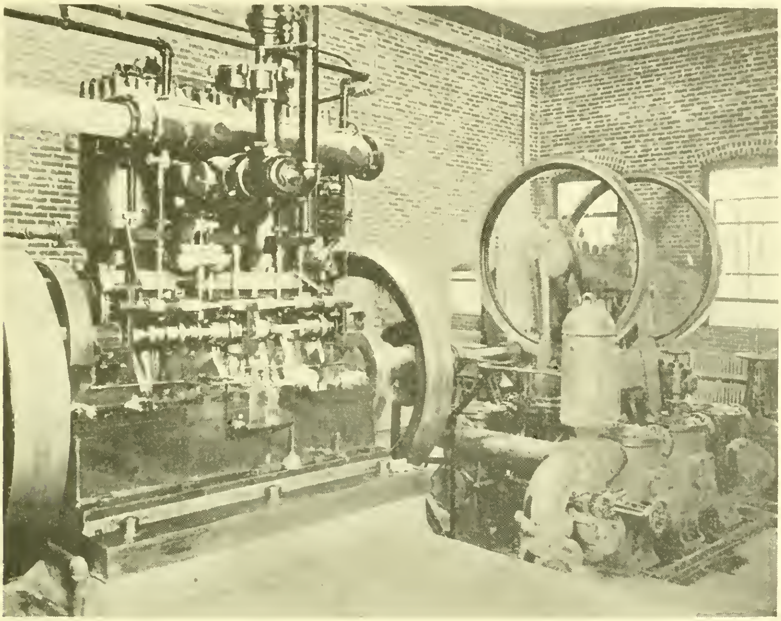


Fig. 11. Triplex Pump Direct Connected to Producer Gas Engine. Water Works, Town of Manchester, Mass.

The above illustration shows a modern gas engine driven triplex pump. The pump has a capacity of 1 000 000 gal. in twenty-four hours, against a discharge pressure of 240 ft. On continuous service this unit has shown a duty of 140 000 000 ft.-lb. for 100 lb. of coal.

A unit of this type is highly economical and thoroughly reliable. Although this particular pumping station burned down at one time, the pumps mentioned were very slightly damaged and with minor repairs were again put into operation and are running as satisfactorily as ever.

operating conditions and possible variations therein will often upset all calculations on comparative yearly cost of operation, which is the basis upon which most pumps are selected.

There is another question which often has to be kept in mind, and that is possible future developments as regards enlargements or changes in the pumping requirements. In laying out a new plant it is particularly desirable that not only the existing conditions be considered but that any reasonable changes or future developments be anticipated. By keeping in mind these facts and following in a general way the rules laid down for

figuring comparative yearly cost of operation, the proper selection of a pump should be a comparatively easy matter in every case.

Installation and Operation.

Having decided upon a proper type of pump, a word with regard to the proper installation and operation of such units may be of interest and value.

Generally speaking, careful attention should be paid to the location of any pump, particularly with regard to the suction conditions. It is very desirable that pumps always be installed as near the water as possible, that the suction lines be as short as possible and of liberal size, and that every precaution be taken to prevent leakage of air in the suction line. All pumps should be placed on adequate foundations. As far as foundations are concerned, it is not necessary to provide as large or heavy foundations for centrifugal pumps as are required for reciprocating units. In every case, however, adequate foundations should be provided to prevent settling or undue vibration on the units.

Piping should be given special attention, and all unnecessary fittings, bends, or any restrictions should be avoided.

In operating any type of unit it should be borne in mind that a pump, like any other machine, requires a reasonable amount of attention. Pumps in water-works plants usually are given fairly good attention. A small amount of attention to the packing of the glands, condition of the valves, lubrication of all working parts, and adjustment of the same, will insure satisfactory operation for a considerable period of time. Inadequate attention to these matters will, however, often cause trouble and result in very unsatisfactory operation, regardless of what type of unit has been selected.

It is hoped that this discussion will be of some value to those having to do with small water-works plants which form such a large part of the total number of water works in operation throughout the country.

The author wishes to acknowledge his appreciation of the coöperation of those mentioned below, whose contributions in the form of information, lantern slides, etc., have been of considerable help and interest:

Allis-Chalmers Co., Power Equipment Co., Nelson Blower Co., Hayes Machinery Co., Goulds Mfg. Co.

Discussion.

[*December 10, 1919.*]

Mr. A. O. Doane.* *Mr. President and Fellow Members,* — The paper of Mr. Fulton, read at the last meeting, and the paper by Mr. Symonds at a previous meeting, taken together constitute a very exhaustive study of the question of small water-works pumping engines, and leave very little ammunition for any one talking on the subject of the construction or design and construction of these small plants.

It seems to me, however, that one side of the subject, and one very important side, would be of a great deal of interest, and that is to hear from the superintendents or others, members of the Association, who have had experience in operating these plants of the various types. This is something that is given very little attention in the two papers mentioned, but is, of course, a very important subject, and one which is of the greatest interest to people that are trying to decide what type of apparatus to install, because, while the proposition presented to them by a salesman of the companies interested may appear very nice, it is quite possible that those who have attempted to operate the apparatus would know of some features, some troubles that have developed, that would be of the greatest importance to the man who has got the matter of deciding which type to select.

As was said by Mr. Fulton, and his paper brought out very clearly, the two principal types of pumps which are considered now are the reciprocating type and the centrifugal type. On the Metropolitan Water Works we have always installed the reciprocating type of apparatus, generally in rather large units, until two or three years ago it became evident that at one of the stations, called the "Arlington Pumping Station," it was necessary to install additional capacity in order to take care of the rather serious peak loads which occurred during a dry time in the summer, and also to enable us to remove, without danger of interruption of the service, a direct-acting pump which was put in some years ago with the idea of keeping this as a reserve pump until the conditions developed which would perhaps warrant putting in a larger pump of a higher-duty type. We have now in this station a million and a half gallon capacity Allis-Chalmers pump, of the cross-compound fly-wheel type. Without a very costly enlargement of the building it was impossible to put in a pump of the reciprocating type. It was desired to have a pump somewhere in the neighborhood of two millions and a half or three millions capacity, and after careful consideration of the subject it was decided to put in a centrifugal pump, largely on the basis of first cost but primarily on account of the smaller space which this unit would take up in proportion to its capacity, and to the fact that no additional foundation in the basement would have to be put in, as the unit would rest directly on the floor of the engine room, which was made of structural steel and concrete arches.

* Division Engineer of the Metropolitan Water Works.

The unit is placed in the station between two other units. On the right is the Allis-Chalmers cross-compound engine, and on the left the direct-acting Blake pump, which was one of the old type. The unit consists of a steam turbine driven centrifugal pump having two pumps arranged in series. The water for this station is taken from a main and pumped into a discharge main at a high pressure; in other words, it is a booster station. The water comes to the pump under a head of somewhere around 25 lb., and is put out at something over 150 lb. The entire head pumped against at full speed of this 3 000 000-gal. unit is in the neighborhood of 320 ft., which includes the static head and the friction.

The steam turbine was built by the Moore Steam Turbine Corporation, of Wellsville, New York. The centrifugal pumps are Allis-Chalmers. The unit was installed by The F. A. Mazzur Company, of Boston. The discharge pipe from the low pressure pump passes under the bed plate, through a channel in the small concrete foundation, and connects with the suction of the pump that discharges into the high-pressure main. The reason for this arrangement is that a slightly better duty can be obtained by using two pumps in series in this manner, and also that the balancing effect on the propellers is better, and that the unit as a whole is more accessible and considerably more convenient than a two-stage pump where the stages are enclosed in one casing.

As the speed of the turbine is 5 000 revolutions per minute and the speed of the pump is about 1 175, it is evident that a reduction gear had to be used. The gear is between the turbine and the first pump. It is of the double herring-bone type with a pinion and gear enclosed in a cast-iron case, and is lubricated by jets of oil pumped between the teeth that are about to engage. This gear was furnished by the Moore turbine people, and was cut on a very accurate gear-cutting machine in their factory.

I think a word might be said about this gear, or the subject of gears in general, because in using the centrifugal pump, unless motor driven, it is nearly always advisable or necessary to use gears, either reducing gears or gears that will increase the speed, if they are being driven by oil engines or other slow-speed engines. The gears are a very troublesome part of the proposition in many cases. A common trouble with gears is excessive noise. In some cases this is very objectionable indeed, and they emit a shrill screech that is not only disagreeable but renders it impossible to maintain any conversation in the neighborhood.

The question of gears seems to resolve itself into, in the first place, having the tooth of approved form; next, to see that the tooth is cut on a machine with the greatest possible accuracy; third, that the gear and pinion are assembled with very great care and that the material of which the gears are made is the best possible to obtain. Under these circumstances gears can be made which give very good satisfaction over a long period of time. Of course, when a gear begins to wear, the noise increases very

rapidly to such a point that generally it has to be replaced with a new one. As I stated, this pump is primarily used as a reserve pump; it is not run in regular service, so that we have not had an opportunity to see how this gear would stand up under continuous work. I have, however, had an opportunity to see and hear a set of gears precisely like this at several times during a period of about a year, during which time the gears have been run on an average of about sixteen hours a day, and, much to my surprise, these gears actually ran with less noise at the end of the year than they did the first time I heard them; so that it gives us considerable encouragement that this particular gear will stand up under a good deal of service.

The question of the turbine is, of course, another important matter. It is a good plan to have the speed as low as the conditions will warrant. As, however, the speed of the turbine is a considerable factor in economy, owing to the high velocity of the steam in the turbine nozzles, there is a decided temptation to run the speed up, especially as you can get with the highest speeds greater economy at less cost.

This particular machine has seven stages and runs at 5 000 R.P.M.

Small turbines of the single-stage type, which are quite common, are rather wasteful in the use of steam, but where the first cost is a primary consideration it is necessary in some cases to put them in. With a turbine of a reasonable size and about seven stages, they will give approximately the same economy as the steam end of a cross-compound pumping engine. The centrifugal unit is badly handicapped by the comparative inefficiency of the centrifugal pump. The contractor guaranteed the efficiency of the Arlington pumps alone at 73 per cent. We actually got a little better than that, about 75½, on our test. With the larger size pumps, however, it is quite possible to better this very much, and now they have gotten well up to 90 per cent. efficiency with a properly constructed centrifugal of considerable size, say, a fifteen- or twenty-million-gallon unit. In order to get this economy the design has to be very good, and the workmanship of the best, and also a considerable amount of bronze used, — more than in an ordinary commercial pump. The sides of the casing and the propeller should be bronze, with all surfaces finished as smooth as possible. These refinements cost considerable money, but are really worth while if you are going to have a pump which will give the best results in daily service.

This pump has a water pipe leading into the stuffing box. This is a water seal which is used to prevent leakage of air into the pump in ordinary use. It also has some effect in keeping the bearings cool. In our case, of course, the water is under pressure all the time, and we do not require them as a means of sealing the vacuum.

On the sides of the propeller there are what are called "wearing rings." These are composition rings which are fitted to the sides of the propeller, and a corresponding ring is fitted to the side of the pump casing. The object of these rings is to prevent slip or the leakage of water from

the discharge to the suction side of the pump. These wearing rings are quite important, and it is quite a study to get just the right type of ring, and also to get a clearance which will allow the pump to operate without the rings sealing or welding together through touching, and yet will not be large enough to allow an excessive amount of slipping. The advantage of having separable rings is, of course, that if the passages wear, as they will, through the high velocity of leakage through them, it is comparatively easy and cheap to replace them with other rings. We have at Clinton an electrically driven pump which is handling sewage. We make the wearing rings out of cast iron, because sewage carries considerable grit, and it is necessary to replace them about once in three months. If we had to replace the propeller and the casing in that time it would be rather a serious matter.

One drawback, to the centrifugal pump, is that you can't tell without a meter of some kind how much water you are pumping. In our case, there is a 16-in. Venturi meter in the discharge line, so that we can keep track of the pumpage. But in the small pumping station it is possible that the cost of the Venturi meter would be prohibitive.

The centrifugal pump is quite seriously handicapped now, and it looks from the coal situation as though it would continue to be increasingly handicapped in the future, by the very high cost of coal. Under such circumstances, of course, it pays to spend considerably more money and install a reciprocating type if it is going to be used in regular service. I hope that we may hear something from some of the people here that have had experience in operating these, and also in operating other types spoken of in the papers, such as the oil engines and gas-producer engines.

In investigating this subject I have visited plants operated with oil, with producer gas, gasoline, and electricity. Some features of the operation of these different plants that have come to our notice might be of interest. It is found that when operating with producer gas it is very difficult to keep the odor of the gas from escaping and from perhaps annoying neighbors, and it has always been very apparent in the stations. There has always been a strong smell of gas. Another feature which it has in common with the oil-operating engines, or any explosion type of motor, is that it is very difficult, if not impossible, to muffle the exhaust satisfactorily so as not to cause annoyance to people living in the neighborhood, and even in some cases, as the Boston Elevated found out in Medford, to people who live a very considerable distance away. I think it is sometimes impossible to muffle it so as not to cause serious annoyance, not only to people near by, but if the station sets on a ledge, or near a stratum of rock, the vibration is sometimes carried a long distance, perhaps a mile or more.

One of the latest developments, perhaps, in pumping engines, is the application of the Unaflow principle to the steam cylinders of pumping engines. This type is being experimented with by the Worthington

Pump and Machinery Corporation, and Mr. Decrow, I think, told you something about it at Albany.

Mr. Frank A. Fuller. At Wellesley we have a 1 400-gal.-per-minute pump operated by an electric motor. It is gear-connected, and we have the trouble that Mr. Doane has mentioned, — a great deal of noise, — and it is a very serious trouble, it seems to me. While we have run the pump quite a number of years, we have made out to get along with this troublesome noise, which, as he says, prevents hearing conversations, and is very troublesome.

FREDERIC PIKE STEARNS.

Frederic Pike Stearns, long a member of this Association, died at Boston, December 1, 1919.

Mr. Stearns was born at Calais, Me., on November 11, 1851. Like many another country boy, naturally industrious, energetic, and capable, he quickly sought the opportunities of advancement afforded by a great city, and at the age of eighteen, after graduating from the high school of his native town, he came to Boston seeking employment.

In his case no time was lost in groping for the work he was best fitted to do, as so often has happened in cases where men have afterwards made a notable record in the world. Through a casual acquaintance, it is said, he first obtained employment in the office of the city surveyor at a time when municipal engineering in this country was in its infancy and the construction of the great water-supply systems had practically only begun. Such preliminary education as he possessed would ordinarily be an insuperable handicap to the highest success in a profession like engineering, but to great natural capacity were added in Mr. Stearns's case an energy and industry that would not be denied. By devoting his spare hours to study, and by diligent application, he soon became proficient in the knowledge of those subjects required in his work, and ultimately acquired both that thorough education in technical matters pertaining to his profession for which he was distinguished and the broad general education which was so useful to him in after years.

Municipal engineering was at that time just beginning its rapid development, and in this period a remarkable group of men rose to the forefront in the profession in Boston, including J. P. Kirkwood, E. S. Cheseborough, J. B. Francis, Joseph P. Davis, Hiram F. Mills, and others, whose example was an inspiration in the development of younger men; and under the leadership of this group Mr. Stearns began his professional career.

In looking through the records of the Engineering Department of Boston, we find him soon engaged in responsible work. At the age of twenty-one he was employed as assistant engineer in the preliminary investigations for the Sudbury water supply of the city of Boston, and two years later as engineer in charge of the construction of a portion of the works. In 1880 he became connected with the construction of the main drainage works of the city of Boston, a system of sewerage so admirably adapted to the conditions it was designed to meet that with little change it has served its purpose to the present day. The most important portions of this system, the tunnel under Dorchester Bay and the outfall works at Squantum and Moon Island, were constructed under Mr. Stearns's direction as assistant engineer associated with Mr. Joseph P. Davis, who was then city engineer.

FREDERIC P. STEARNS.

Upon the completion of this work, Mr. Stearns was engaged for a short time as chief engineer in the design of the Stony Brook improvement, which was subsequently constructed in accordance with plans he devised. In a certain sense this was pioneer work in this country in the intelligent and scientific study of storm water problems.

In 1886 he was called by the State Board of Health to the position of chief engineer of that board. The State Board of Health had just been reorganized by the legislature, and, upon the recommendation of a commission of far-seeing citizens of which the late John Quincy Adams was chairman, had been charged with the oversight and care of the inland waters of the State, and given the power to advise its municipalities and citizens upon all matters pertaining to water supply, drainage, and sewerage, and the prevention of the pollution of inland waters, for the purpose of protecting the public health, promoting comfort, and improving the living conditions of its inhabitants. The remarkable body of able men charged with this responsibility, under the leadership of Dr. Henry P. Walcott, chairman of the board, and the inspiration of Mr. Hiram F. Mills, its engineer member, gathered around them the most notable group of practical scientists ever up to that time associated for public health work. The work of the board was new, no precedents existed, and the law under which the work was carried on attached no penalty in case of neglect or refusal to follow its recommendations or abide by its decisions. These decisions, in the language of those who planned this new departure in public service, were to "look for their sanction to their own intrinsic sense and soundness"; and the great influence in all matters pertaining to its work which the State Board of Health quickly acquired was due in great measure to the thoroughness and sound judgment, combined with the tact and fairness, of its chief engineer. His keen and exhaustive study of the water supplies of the State set a new standard for scientific investigations, while his tact in dealing with officials with whom he came in contact and his steadfast courage in insisting upon the right course of action secured the confidence of the public in the findings of the board and established a means of controlling and improving the water supplies in Massachusetts which has become the basis of the practice in other states.

Among his notable contributions to general knowledge made in this period were his studies of stream flow and storage, establishing the principles of the economical development of the yield of watersheds which were afterward used generally by the engineers of New England. His great interest in and knowledge of this subject led to his appointment by the New England Water Works Association, at a later time, as chairman of a committee on yield of watersheds. The report, presented in 1914, which was largely his own work, furnishes the basic facts of the yield of watersheds in New England in one of the periods of greatest deficiency that has ever occurred there, and presents an interpretation of them characterized by that clearness and simplicity notable in all his work.

His earliest important work as chief engineer of the State Board of Health was in connection with the investigations conducted by the board relative to a proposed sewerage system for the Mystic and Charles River valleys, the plans for which when presented by the board to the legislature were promptly accepted and carried out. Another notable work of this period was a plan for the creation of the Charles River basin by the construction of a dam in the neigborhood of Craigie Bridge, and it was with his aid as consulting engineer that the estuary of the Charles River has been converted from a foul and offensive channel into an attractive waterway, already a place of recreation for the great population living in its immediate neigborhood and destined to become one of the most beautiful water parks in the world. In this work Mr. Stearns became associated with Charles Eliot, of the firm of landscape architects, Olmsted, Olmsted and Eliot, who were called by the board to assist in the design. This association no doubt gave him the inspiration and indicated some of the opportunities to develop more fully one of his remarkable characteristics as an engineer, — that of making engineering structures beautiful and attractive even though designed for most utilitarian purposes.

His final and crowning achievement during his connection with the State Board of Health was a plan for a general system of water works for the supply of the city of Boston and the numerous adjacent municipalities. To the study of this problem he brought the experience acquired in his studies and investigations of the water supplies of the State and also that knowledge of the needs and requirements as well as the desires and prejudices of the people for whose health and comfort this great water supply was devised.

Upon the adoption of the plan by the legislature and the creation of the Metropolitan Water Board, Mr. Stearns resigned as chief engineer of the State Board of Health, became the chief engineer of the water board, and carried out the great work he had devised. This work was begun in 1895 and completed in 1907, at a cost of $40 000 000. The problems encountered in this great work involved the design and construction of the Wachusett dam and reservoir and its earth dike, one of the most notable structures of its kind in the world. The plan included that novel feature in public water-supply development, the utilization of the fall of the water into the aqueduct for the production of power — an innovation which has produced a very considerable revenue for the metropolitan water district. The construction of the Wachusett Reservoir illustrates one of his greatest contributions to engineering development in this country. The ordinary reservoir in New England in earlier times has often been a scar on the landscape, and even those constructed for the purpose of supplying drinking water were not uncommonly scenes of depressing desolation. The Wachusett Reservoir, named for the mountain which is the most conspicuous feature in its watershed and of the hill country of central Massachusetts, has been made one of the most beautiful lakes in New England, and even

the lines of the dams and the other appurtenances of the system have been softened to unobtrusive and even attractive features in the landscape. Spot Pond, the northern distributing reservoir of the metropolitan system, always the gem of that wonderful expanse of unspoiled wilderness known as the Middlesex Fells, has been made to retain its most attractive features, notwithstanding the fact that the changes necessary to adapt the pond to its new purpose included raising its surface ten feet above the original level.

The same is true of the other reservoirs and their appurtenances built in connection with the metropolitan water works. Pumping stations, gate houses, and other wholly utilitarian structures have not only been made architecturally attractive, but have been placed in pleasing and often beautiful surroundings.

This belief in the value and importance of attractive structures for the storage and delivery of water to be used for drinking was an outgrowth no doubt of that basic principle which underlies all of Mr. Stearns's work, — that a public water supply being, after pure air, the greatest essential to life and health, should be the best that under the circumstances could possibly be obtained, since no food or other article of diet is capable when impure of causing more serious injury. He believed that, with the limitations in our knowledge of the effect of the character and quality of drinking water upon health and life, everything should be done to secure a water of the highest natural purity, that all of the natural processes which tend toward its improvement should be availed of to the fullest practicable extent, and that every effort should be made to maintain the purity thus secured.

The metropolitan water system was his greatest achievement, and there can be no better evidence of his character, his thoroughness in the matter of all details, and the fairness of his disposition, than is found in the records of the great volume of contract work which he handled without litigation. The innumerable settlements with owners of lands and riparian rights, and with other claimants in the large enterprises that were entrusted to his care, were handled with the same unfailing good judgment and faithfulness evident in all his work.

In recognition of his contribution to the advancement of engineering, Harvard University conferred upon him in 1905 the degree of master of arts, and in 1906 he was further honored by the University of Pennsylvania with the degree of doctor of science.

His work at the completion of the metropolitan water system had given him an eminence in his profession which enabled him upon his retirement from the position of chief engineer of the Metropolitan Water Board, in 1907, to choose for his professional work in his later career as consulting engineer the problems which interested him most. These included the water supplies of Baltimore, Los Angeles, Winnipeg, Hartford, Rochester, and Worcester. He had been consulting engineer for the Board of Water Supply of New York City since 1905, and for the new water supply at

Providence since 1914. He was also consulted with regard to the construction of the Chicago drainage canal, the Mississippi power dam, and other projects in the West and in Mexico. He was one of the engineers selected by President Roosevelt to advise as to the construction of the Panama Canal, and was influential in procuring a canal with locks.

His influence was felt indirectly in a far wider field on account of its effect upon the engineers with whom he became associated. His cordial appreciation of good work, wherever it was found, and his deep interest and great assistance in the work of all engineering societies, will long be remembered, and he will be greatly missed by all with whom he ever came in contact.

Tall, erect, of excellent figure, gentle and pleasing in manner, and ever willing and patient in aiding and advising younger and less experienced members of his profession, but facing with undismayed courage and unfailing courtesy the most strenuous opposition, his was a strong character and a pleasing personality. Death claimed him before his strength declined or age had caused his powers to fail, and so we shall remember him strong and faithful, patient and kindly, with a courage that never faltered and a modesty that effaced all thought of self. It was his privilege to accomplish more for improving the lives of others than often falls to the lot of man.

X. H. Goodnough,
Leonard Metcalf,
Committee.

March 10, 1920.

THE PREVENTION OF THE RED-WATER PLAGUE.

BY WM. H. WALKER.*

[*November 12, 1919.*]

People who live in districts supplied with soft water — such, for example, as the New England States and New York City — are familiar with what has been termed the "red-water plague." This condition of the water is caused by the presence in it of hydrous red oxide of iron, commonly spoken of as rust. The fact that this oxide of iron is present in the water means that the iron pipes of the hot-water supply system have been correspondingly corroded by the water, and have been pitted or otherwise weakened in proportion to the amount of iron removed. Thus the iron is taken from where it is needed, namely, the walls of the pipes, — and placed in an objectionable form where it is not wanted, — namely, in the water. Many factors incident to modern city life have united in greatly increasing the daily consumption of hot water, and the loss, due to failure of pipe lines through clogging by deposited rust, as well as leaks due to pitting, has now become a most important problem.

A great deal of very valuable research has been devoted to the causes of the corrosion of iron, notably by the Massachusetts Institute of Technology; and the seed sown by the early investigators is now beginning to bear fruit. It was for many years thought that rust was formed by the direct union of the oxygen of the air, water, and the iron. Now we know that such is not the case.

The Modern Theory of Corrosion. Iron has a perfectly definite tendency to dissolve in water, with the separation of an equivalent amount of hydrogen. If there be no impurities of any kind present in the water, this solution proceeds but to a very slight extent. The surface of the iron becomes covered with a protecting layer of hydrogen, and the action ceases. If free acid exists in the water, or a substance, such as alum, be present, which upon heating liberates an acid, this hydrogen may be thrown off in the shape of a gas and the solution of the iron proceed with great rapidity. On the other hand, if an alkali such as caustic soda be added, not only is the acid neutralized and this action prevented, but the water itself is less active in its attack upon the iron.

Natural water, however pure it may be, is saturated with the oxygen of the atmosphere. While oxygen and iron do not directly unite except at a high temperature, yet the presence of oxygen dissolved in water has a controlling influence upon its ability to dissolve or corrode iron. This effect is produced by the reaction of the dissolved oxygen upon the hydro-

* Professor Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

gen film, with which, in the absence of oxygen or free acid, the iron protects itself. Slowly but surely this hydrogen film is destroyed and the corrosion of the iron proceeds.

When the iron dissolves in the water it exists in the difficult soluble form known as ferrous hydroxide. With this material oxygen readily unites, forming the well-known ferric hydroxide or rust. This formation of rust is a secondary reaction, and is a consequence of, not the cause of, the solution of the iron in the first place.

It is clear, therefore, that if all the dissolved oxygen be removed from water, the protecting film of hydrogen will not be destroyed, and the solution of the iron will cease. In other words, by taking out the dissolved oxygen, the cause of the continued corrosion is also removed. In any given amount of water in contact with iron the dissolved oxygen content is therefore removed in two ways, — first, the portion which unites with the hydrogen protective film, and, second, that portion which unites with the ferrous hydroxide.

Practical Consideration. It has been frequently observed that corrosion in boilers is more marked near the feed water entrance, and in hot-water supply systems it was found that over half of the free oxygen was removed by corrosion of the interior of the heater, and most of what remained was taken up by the pipes of the system before the water was drawn. It appeared from laboratory experiments that corrosion practically ceased with elimination of free oxygen, and is directly proportional to the oxygen contents of the water, other factors such as temperature and amount of make-up water being constant.

These facts led to the installation of an experimental plant for the removal of oxygen from hot water in the Irene Kaufmann Settlement House in Pittsburgh, December, 1915, where considerable trouble had been experienced with rusty water due to corrosion of iron pipes. The principle employed is to fill a storage tank with suitable prepared steel lathing (26 B. W. G.) which will pack so as to have an exposed surface of approximately 100 sq. ft. per cubic feet of space. In passing the water heated to 160° Fahr. through this metal, all the oxygen is fixed in the form of hydroxides, which are readily removed by filtration through an ordinary sand filter. The result is water inactive toward iron or other metals, free from oxygen but otherwise unaltered in composition except for the presence of a small amount of free hydrogen resulting from solution of iron in the "de-activating" tank. The results have been entirely up to expectations based on research work previously done, as the pipes carrying de-activated water have shown no perceptible corrosion in nearly four years' service, whereas before this system was installed some of the pipes were nearly destroyed in this time. The corrosion in the old piping has evidently been arrested, as no further pit holes developed after the plant had been in operation a few weeks.

Another plant was installed by us in Boston in a twenty-six dwelling

apartment house in March, 1917, to afford further study of this problem in practice under different water conditions. The design was somewhat different from the first plant described above, but the results have been equally satisfactory. Details as to the operation of these plants, which were necessarily more or less experimental, will be found in a paper on "The Preservation of Hot-Water Supply Pipe in Theory and Practice," by Speller and Knowland, Transactions of American Society of Heating and Ventilating Engineers, 1918.

The installation to be described was designed for a large twelve-story apartment building of the best type, which was constructed in 1918 on the block between Park and Madison avenues, 47th and 48th streets, New York. This was designed to de-activate 6,000 gal. of water per hour at a temperature of 160° Fahr. The size was over ten times that of any previous plant which had been operated, and presented some problems which could not be solved without experience on this scale. Some changes in the piping arrangement and filters were found necessary to put the plant in satisfactory working order, as shown in Fig. 2.

Description in Detail. The water-heating equipment is divided into two independent sections, supplying the east and west buildings. The arrangement is the same for both, therefore only the equipment for the west building is shown in detail. Fig. 1 indicates the main features of this plant in diagrammatic form. This consists of two steam heaters and storage tanks of the usual type, the outlet of which is connected with the top of a de-activating tank 15 ft. long and 5 ft. in diameter, filled through the manhole at one end with strips of steel lathing supported on cross bars 4 in. above the bottom of the tank. The water is drawn off at two places from the bottom of the de-activating tank and passed through ordinary sand filters arranged in parallel as shown. From these filters the water is passed through the system and is circulated by means of centrifugal pumps through return lines and a small booster heater to the filters and back to the system again. In this way only the makeup water is passed through the main heaters and de-activating tanks. One of the heaters has been filled with steel lathing above the heating coils. Our experience with this arrangement indicates that with storage capacity slightly greater than that usually provided in such heaters it is possible to heat and de-activate the water in one tank as shown, but it is desirable in such cases to have two tanks to provide water when either one of these tanks require cleaning. Recording thermometers are provided at the heaters and in the main from de-activator before the water enters the filters. In circulating the water through the building the temperature is reduced 25° to 30° Fahr., which is made up in the small booster heater. By this treatment, with a maximum flow of 5 000 gal. per hour, the free oxygen is reduced to less than 0.10 c.c. per liter. In the previous installations described in Pittsburgh and Boston, the average oxygen contents in periods of maximum use of water runs about 0.2 c.c. per liter without showing noticeable corrosion in nearly four

years' service. The conclusion we have reached is that this plant has been designed somewhat too large for the building, in so far as de-activating space is concerned, but affords valuable information for the proper proportions for other installations under similar conditions. In designing this installation it was the intention to do some experimental work, so the piping system around the filters was laid out in more complicated form than would otherwise have been necessary for regular practice.

While there may be other means for removing oxygen which will reduce corrosion to a minimum, such as heating the water nearly to the boiling point in a vented tank, the method described has the advantage and simplicity of being automatic in that only as much iron is taken up as is necessary to fix the free oxygen, so that several years' supply of sheets may be kept in the storage and de-activating tank. Furthermore, the water need not be heated above the temperature at which it is required for use, and no attention is needed except for the regular periodic reversal

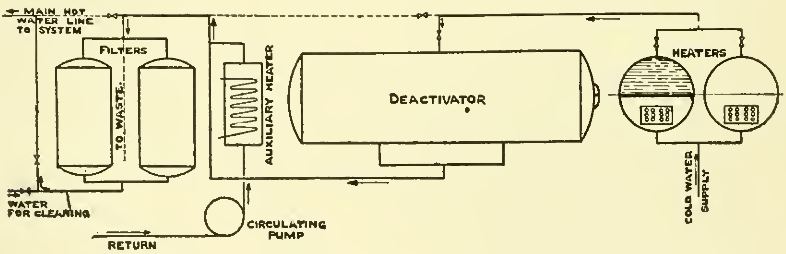
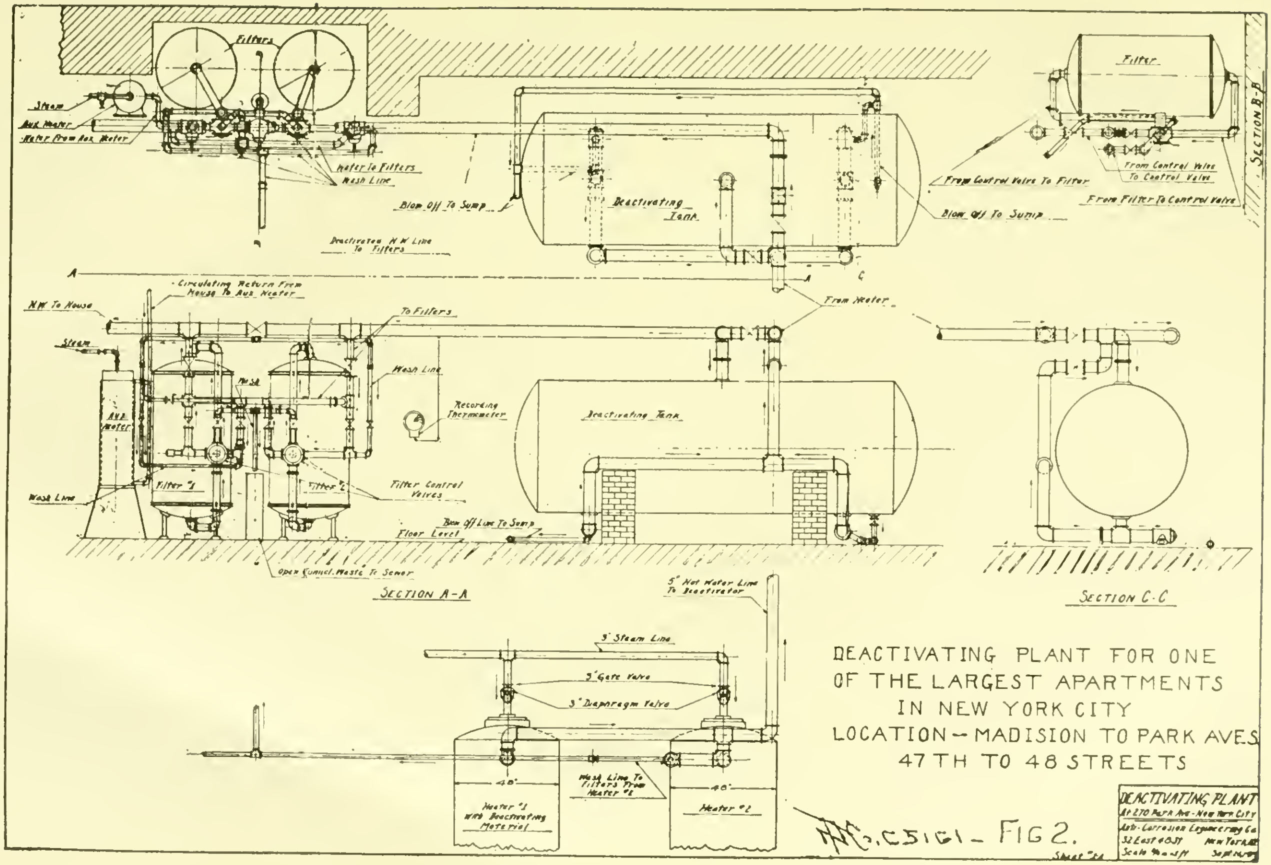


FIG. 1. GENERAL DIAGRAM OF PLANT FOR DE-ACTIVATION OF WATER, 48TH STREET AND MADISON AVENUE, NEW YORK.

of the filters, which can be readily attended to without the aid of an engineer; so that, with the exception of the interest on initial cost of installation, the cost of treatment may be said to be very little more than the cost of renewing the de-activating sheets from time to time. No allowance is required for deterioration of tanks or filters, as there is no reason to anticipate any serious corrosion of these parts during the life of the building, and for the same reason this should be true of the heaters when filled with de-activating plates.

Galvanized steel pipe was used in the installations described. Without de-activation, the life of wrought iron or steel under such conditions in large hotels, apartments, and similar buildings in New York City is about seven or eight years. Brass pipe will probably not show evidence of deterioration from this cause until a few years longer, as the water is not discolored by the products of corrosion in this case. Brass pipe is, however, often seriously weakened and ultimately destroyed by de-zincification, which is also largely prevented by de-activation of the water.

We believe that the problem of preventing corrosion in feed-water pipes and boilers can be solved in a similar manner by removal of the free



No. C5161 — FIG 2.

oxygen. Where makeup water is comparatively pure there is no doubt that reduction of the free oxygen to 0.10 c.c. per liter will practically eliminate this trouble.

Economizers are particularly subject to rapid corrosion where the feed water is not de-activated, and for this reason the heavy walled cast-iron tubes have been used for this purpose at a sacrifice of safety and efficiency. The use of de-activated water makes possible the use of standard charcoal iron or steel boiler tubes in economizers.

In these times economy and conservation of material mean so much to the world that we feel no apology is necessary in calling the attention of engineers to a rather neglected branch of their profession, — *anti-corrosion engineering.*

Discussion.

Mr. Robert Spurr Weston.* I do not want to let the afternoon go by without saying how much interested I have been in Professor Walker's paper. It is a very ingenious device indeed which he has brought before us for discussion. The idea of adding iron to water and letting it do its worst on that rather than on the pipes themselves is very ingenious.

With regard to what Professor Walker has said as to the degree of acidity or alkalinity which a water must have in order to get good coagulation, I should like to say that we have had a good many cases where we have had to study to find out the point of alkalinity above which there would be almost no coagulation and below which there would be sufficient coagulation. We have one of our assistants at work on a case where too much alkalinity had been added, and where it effected the solution of the suspended matter which ought to have coagulated.

There is a red-water plague of another kind which has occurred in Brookline within ten days, which you might be interested to hear about. On the 2d of November the water drawn from the taps in certain districts of Brookline began to run black; in fact, there was a quarter of an inch of black colloidal hydrate in the bottoms of tumblers of water drawn from the taps. Mr. Forbes, whom we all know, was very much exercised about it, as his telephone rang continuously, and he was forty-eight hours without having his clothes off, flushing, entreating people to have patience, looking for various causes of the trouble, etc. You will remember that about three years ago Brookline determined to purify its well-water supply, which at that time and now contains iron and manganese. The unpurified water was discharged into the mains for years, and it left a deposit — there must have been tons — of iron and manganese hydrate attached to the insides of the pipes. There was a 24-in. and a 16-in. main which ran from the Cow Bay Pumping Station about 20 000 ft., which contained a great

* Of Weston & Sampson, Consulting Engineers, Boston, Mass.

deal of this rusty matter, — iron and manganese rust. These metals had not dissolved from the pipes, but had dissolved from the soil by the very same chemical action which Professor Walker has described so clearly. Last summer Mr. Forbes made a very thorough cleaning of his force main, and got out everything that high velocity could remove from the pipe; but, as I said before, on November 2 a plague of black rust appeared at the taps. The trouble increased for a week, apparently reaching its climax about last Wednesday.

It was found that the rust on the walls of the pipe consisted of more manganese than iron. Apparently the iron which had been deposited — it is a well water which, by the way, contained about five times as much iron as manganese — had been largely removed by previous flushings, leaving a deposit containing two and a half times as much manganese as iron. This adhered to the walls of the pipe, until something occurred which caused it to slough off and brought it into the circulation.

Day before yesterday Mr. Forbes cut into the main and found that the surface of the iron pipe itself was untouched, — that is, the asphalt coating was intact, — and all the time the water coming from the deferrization plant had no manganese at all in it and was practically free from iron, was saturated with oxygen, and contained only five or six parts of carbon dioxide per million.

We were called in to ascertain the cause of the trouble, and a possible explanation is that the accumulation of gelatinous organic matter which came from the soil originally and which acted as a cement to attach this coating to the walls of the pipe, had gradually been oxidized by the action of bacteria, setting free the powdery material which dropped off the pipe, got into the water, became hydrate, and was carried on to the consumer. We have shown by bacteriological tests that there has been a gradual oxidation of this coating.

Two years ago, when the deferrization plant was started, the force main, about 20 000 ft. long, and 16 and 24 in. in diameter, discharged 3.8 million gal. in twenty-four hours. Before this last pealing off of the coating occurred they could discharge about 4 million gal. in the same time, and to-day they discharge 5 million gal. with ease.

Col. George A. Johnson.* Reduced to its lowest terms, and stripped of that mysterious verbiage which chemists are as prone to use as the medical man is to camouflage his sugar pills under a Latin name, red water is water containing iron rust. Furthermore, it is rare that water contains enough iron rust to give it a red appearance; but the water man would not be entirely satisfied unless he tagged every significant and some insignificant water defects with a sinister name. "Red water" and the "red-water plague" are examples.

You have just listened to a paper on red-water troubles prepared by an authority. Few men are better qualified to discuss this subject than Pro-

* Colonel, U.S.A., Utilities Division, Construction Division of the Army.

fessor Walker; particularly as regards the causes of so-called "red water." In some of his writings the speaker has discussed red-water troubles in an elementary way, essentially as regards alleged causes; but, as these writings will disclose, he has paid more attention to what he considers the negative phases than to those probably having a positive relation to the cause of the appearance of iron oxide in water.

Water initially containing even very small quantities of iron in solution will, upon exposure to the atmosphere, precipitate that iron as a red deposit. Certain agencies, some of which in all probability are as yet undiscovered, have a solvent action on iron and steel pipes, and thus iron rust is added to water flowing through such pipes. Rain water and even distilled water will dissolve iron.

Carbonic acid is omnipresent. It is usually present in varying amounts in all ground waters and in the majority of well waters. The ground waters of Lowell, Framingham, and Malden, Mass., contain from 7 to 25 parts per million, and the surface waters of other Massachusetts cities at times contain as high as 15 parts per million. There seems to be no fairly precise relation between the carbonic acid content of a water and the degree of "red water" it will produce. There doubtless is a relationship, but closely allied to it, in all probability, is the law of chemical combinations, to put it crudely. Again, red water will be encountered in a row of houses on a street, skipping a house now and then. The varying character of the service pipes is there responsible for the seeming phenomenon.

The opponents of rapid sand filtration or any filtration process wherein aluminum sulphate is used, direct thereat the passionate finger of blame when a red-water flurry pops up in a community where such a process of water purification is used. Within the limits of ordinary practice in the use of aluminum sulphate in water purification, the assumption that the slight increase in free carbonic acid caused by such chemical treatment is responsible for the more or less common run of red-water troubles is fanciful and cannot be substantiated. Red-water troubles are encountered in cities having pure ground-water supplies, as well as in others using the old-style slow sand filtration. The cause is not one common to all cases or localities, but is due as much, and in many instances more, to the natural character of the water supply itself, regardless of the manner in which it is purified.

And, finally, red water is objectionable for some laundry purposes and on esthetic grounds. It has no sanitary significance. Red water leaves a stain on porcelain surfaces and clouds glass containers, and may stain white or light-colored fabrics in laundering. Those are its sole points of significance. It cannot be said to be a red indicator of gross corrosion of water pipes. It is objectionable to the highly developed esthetic sense of the American citizen, however, and consequently a solution of the problem of how it may practically be overcome is desirable.

Mr. Frank W. Green.* The subject of this paper is one that is of greatest interest to the speaker, and it is gratifying to find that a practical method has been worked out whereby this unpleasant trouble may be overcome in a satisfactory manner on a commercial scale. The speaker wishes that he could feel that the problem is as elementary an affair as the author would lead one to believe, but in most municipal supplies there are complications which add to the difficulty of the solution.

The presence of free carbonic acid, the passage of colloidal aluminum hydrate through the sand beds of rapid type filters, and in some cases (and the speaker believes these to be of far more frequent occurrence than is generally realized) the presence of appreciable quantities of manganese is an important factor that has to be taken into consideration.

Where you have a water containing suspended matter, due either to natural turbidity or to the hydrate incident to purification by means of sulphate of alumina, there will be a coating deposited on any iron placed in the supply for the purpose of reducing the oxygen content, and therefore special means must be provided to prevent or remove such coatings, or else no action will take place. What appears to be a catalytic action has been noted in some supplies; iron placed in a small quantity of such a water kept on rusting for several months. This is important.

The speaker would like to ask Dr. Walker just what effect the presence of carbonic acid and of manganese has on the problem, and why any brass object that is connected in a water pipe will cause the corrosion of the iron pipe in its vicinity to become greater.

In regard to the use of lime at Little Falls, the speaker would like to say that lime has been used successfully at various times for the reduction of the corrosive action of the supply, but that it was found to be impossible to entirely eliminate corrosion by this means; nor was it practical to coat the inside of mains and house pipes with lime to prevent future recurrences of the trouble. The application of lime in any considerable quantity has several objectionable features, and its use is not recommended except in certain emergencies.

The author has mentioned that oxygen exists in a water supply in two forms: as a part of the water (H_2O) itself and as part of the air which is dissolved in most all natural waters. When water that is high in dissolved oxygen content is subjected to an increase of temperature or pressure, part of this oxygen becomes squeezed out and is held in suspension, — probably colloidal, — to form what may for want of a better term be called "entrained" oxygen. Upon decrease in pressure, this air appears as minute bubbles which gather together and rise to the surface to give the "milky water" which is of frequent occurrence in high-pressure systems as drawn from the tap in cold weather. This form of oxygen is more active than dissolved oxygen, and where it is present the corrosion of iron takes place about as rapidly as on surfaces which are intermittently wetted.

* Superintendent, Filtration and Pumping, Montclair Water Company.

Mr. Melville C. Whipple.* The discussion which has been brought forth by Professor Walker's interesting paper relative to the corrosion of iron and steel water pipes suggests to me some long-time experiments along this line which were recently completed at Harvard University.

A long series of experiments was made at our laboratory in Cambridge several years ago, which showed that differences of potential exist between certain parts of iron and steel plates and pipes. These differences in potential set up galvanic currents within the material, and such currents are known to stimulate corrosion of the metal when moisture and oxygen are present. It was possible by means of a sensitive galvanometer to measure these currents.

Wrought iron of good quality exhibited currents in a slight degree, and steel covered with mill scale, as it comes from the mills, showed striking differences of potential between the metal and the scale, with consequent greater currents. If the scale was removed, almost no current could be measured between portions of the clean metal.

One of the conclusions of this series of studies was the belief that, if steel water pipes of good quality were free of mill scale when put in service, the corrosion problems so common with such material might be greatly decreased. The common methods of doing this make use of pickling acids, brushing, or sand-blasting, all of which are fairly expensive and under some conditions impractical.

The appearance upon the market of the new process "scale free" steel pipe, which has been mentioned at this meeting, made possible the use of a material free from the surface coating which was known to actively stimulate galvanic currents and thereby corrosion. In order to test this new product under service conditions, I made arrangements with Mr. F. N. Speller, of the National Tube Company, a member of this Association, to send me three samples of 1½-in. steel pipe made of different grades of material.

The samples included scale-free pipe, National galvanized steel pipe, and copper steel pipe. A fourth sample, Byer's wrought-iron pipe, was added from the stock at Harvard University. Two pieces each of these four samples, in 4-ft. lengths; were installed April 20, 1916, in the hot-water service line in Weld Hall, a dormitory of Harvard University. Cambridge city water is used in this service.

The pipes were placed near the heater and arranged in a horizontal coil with cast-iron return bends, each of the four sections of the coil having two pipes. The following order was chosen: Galvanized, scale-free, copper steel, Byer's wrought-iron, Byer's wrought-iron, copper steel, scale-free, galvanized. Inasmuch as the balance of the service was brass pipe, the precaution was taken to insulate both ends of this coil from the brass by means of specially made hard-rubber flanges. Couplings between the

* Instructor in Sanitary Chemistry, Harvard University.

galvanized and scale-free samples were of galvanized iron, those between the copper steel and wrought iron were of wrought iron.

The coil remained in service until April, 1919, — that is, for a period of three years. At the end of that time the pipes were choked with iron deposit and had to be removed. This occurred during my absence from the country, and was carried out under the direction of Professor George C. Whipple, of the Department of Sanitary Engineering, Harvard University. The subsequent work of examination and measurement was done by Mr. Gordon M. Fair, instructor in sanitary engineering. This involved a large number of careful measurements to determine the depth to which corrosion had penetrated.

Six-inch sections were cut from each length of pipe, and these were cut in two, lengthwise, in order to lay bare the interior surface. All rust and loose scale was removed, and a survey made of each section by means of a depth gage, in order to determine the depth of pitting. A great many measurements were also made of the thickness of the pipe, both where corrosion was apparent and where it was not.

In the following table all these measurements are summarized.

Thickness of Pipe and Depth of Pitting in Inches at End of the Experiment.

Kind of Pipe.	Thickness.			Max. Depth of Pitting.	Thickness of New Pipe.
	Max.	Min.	Median.		
National scale-free........	.149	.129	.139	.030	.156
National scale-free........	.163	.134	.142	.060	
National copper steel......	.175	.118	.139	.065	.156
National copper steel......	.159	.115	.128	.070	
National galvanized.......	.152	.116	.142	.075	.154
National galvanized.......	.157	.110	.147	.080	
Byer's wrought-iron.......	.211	.124	.147	.065	.152
Byer's wrought-iron.......	.213	.111	.151	.080	

Comparison of the median measures of thickness with the thickness of new pieces indicates that all the specimens lost in average thickness. The wrought-iron and galvanized pipes lost less than did the copper steel and scale-free, due no doubt to the fibrous structure and mixture with cinder in the case of the wrought-iron, and to the protection afforded by the zinc coating in the case of the galvanized. The very high loss of the copper steel may have been the result of mill scale being loosened by the corrosion around and beneath it.

The loss in thickness, however, must not be taken as an indication of the total amount of iron dissolved or the amount of damage done. If

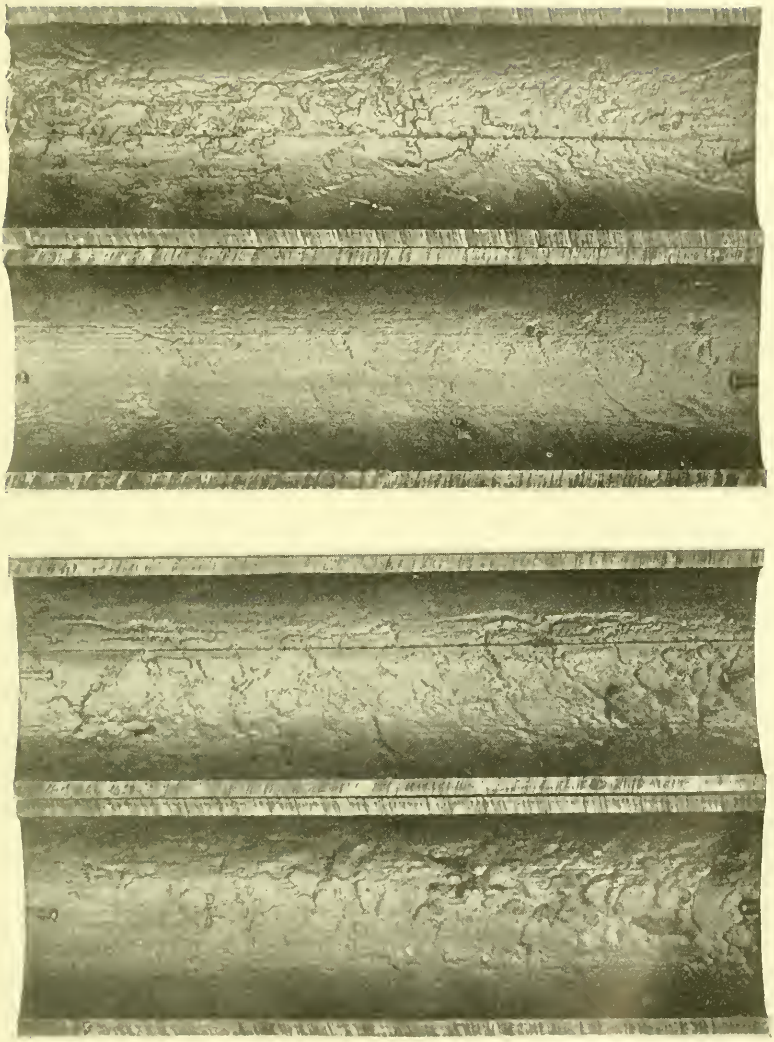
corrosion is accelerated by means of galvanic currents set up in local areas, as much, or more, iron may be dissolved than from a larger area where the rate of solution is less rapid. It is this rapid eating away of metal from small areas that ultimately results in failure by reducing the thickness of the wall to the point where internal pressure is no longer resisted. Thus local corrosion or pitting is the best measure of damage to the pipe.

In the table will be found the depths of the deepest pits encountered by the survey of the prepared specimens. The scale-free pipe exhibited in both lengths of pipe maximum depths of pitting which were lower than any of the others. Specimens of the other three varieties showed but slight differences in the maximum readings, the galvanized pipe being slightly worse in this regard.

A visual inspection of the sections used for examination was of value in determining the general extent of the deterioration suffered by the different pieces. In this connection, attention is called to the excellent photographs accompanying this discussion, which were loaned by Mr. F. N. Speller. The interior surface of each of the eight sections examined is here shown.

Nos. 1 and 4 represent the scale-free material. These pieces were remarkably free from evidences of local corrosion or pitting. Only a few pits were found, and these were not as large, or as deep, as those in the other samples. Much of the roughness seen in the photographs originated during the making of the pipe, and existed before the experiment was made. The uniformity of action over the surface is indicated by the even thickness viewed along the edges where the specimen was cut in two longitudinally, whereas, in the case of the other three materials, the edges vary greatly from a straight line and show the uneven thickness existing after the experiment. This is particularly the case with the specimen of galvanized pipe, which measurements showed to be more deeply pitted than any of the four materials.

Judging from the depth of pitting and the general appearance of the interior surface of the pipe, it was evident that, so far as the conditions of this particular experiment with the Cambridge hot-water service were concerned, scale-free pipe had suffered less real damage than any of the others after three years' exposure. Such corrosion as had occurred took place uniformly over the surface. There were very few pits, and these were neither large in size nor great in depth as compared with those produced in the other kinds of pipe.



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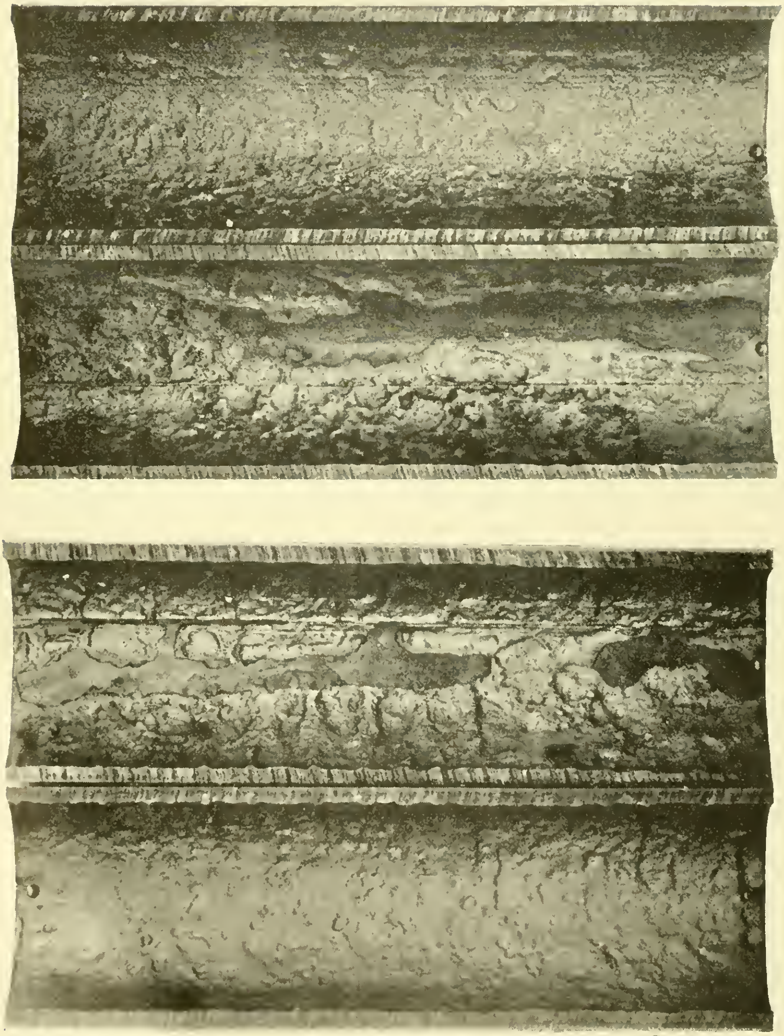
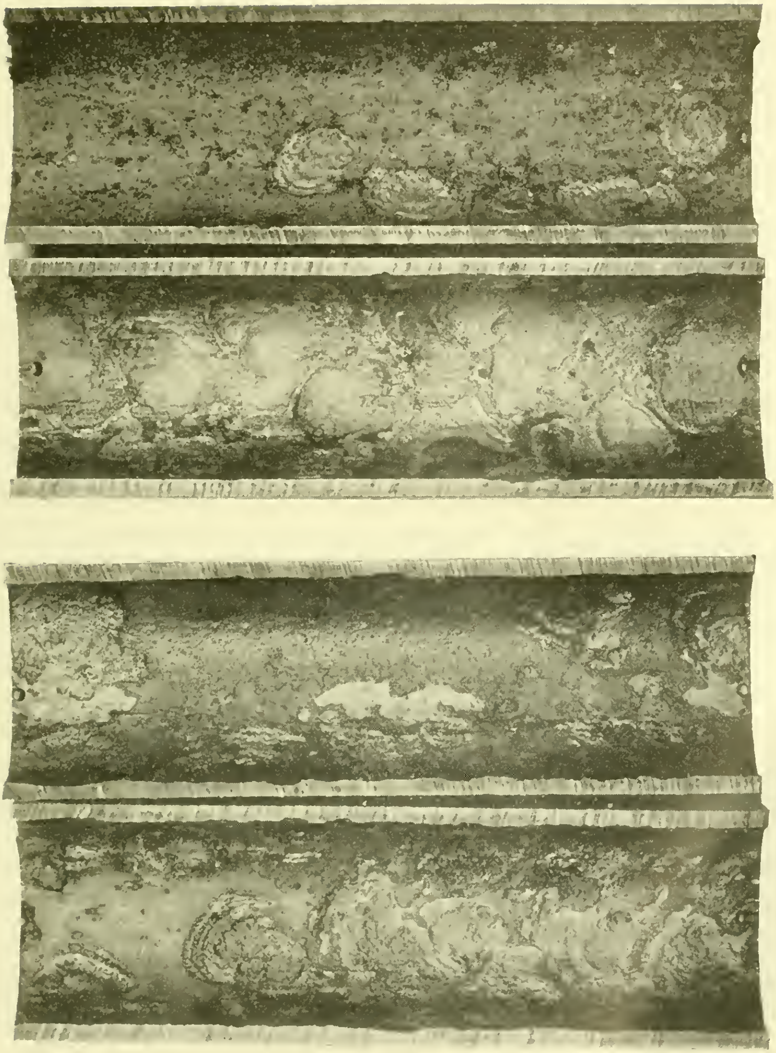
1

TEST IN HOT-WATER SERVICE — HARVARD UNIVERSITY.
NATIONAL SCALE-FREE PIPE.



2 3

Test in Hot-Water Service — Harvard University.
National Copper Steel Pipe.



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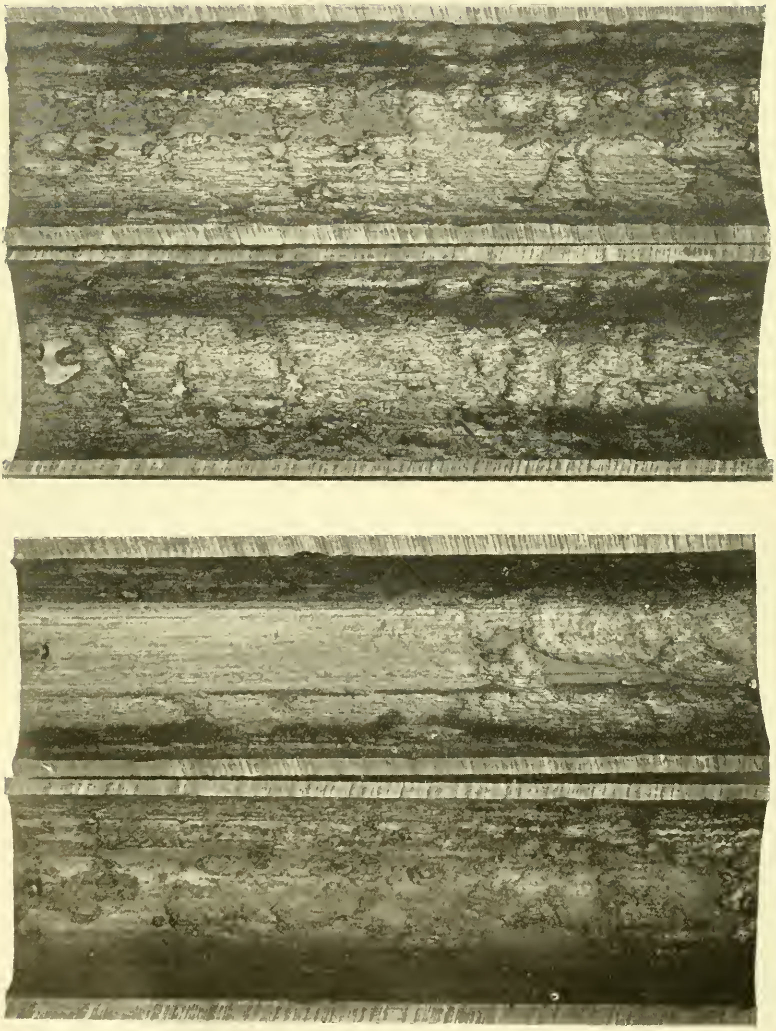
Test on Hot-Water Service — Harvard University.
National Galvanized Steel Pipe.



6 7

TEST IN HOT-WATER SERVICE — HARVARD UNIVERSITY.
BYER'S WROUGHT-IRON PIPE.

SUPERINTENDENTS' SESSION.

October 2, 1919.

Experience meeting, opened by David A. Heffernan, superintendent of water works, Milton, Mass.

Hydrants Broken by Automobiles.

Mr. David A. Heffernan. *Mr. Chairman and Members,* — I have been asked to open the discussion of this experience session, and have chosen as my subject " Damages to Hydrants by Motor Vehicles; Their Repairs and Preventives."

This seems to me to be a subject of increasing importance, growing with the popularity of motors. We have had 8 hydrants and 3 watering posts damaged by collision so far this year. This is not quite 2 per cent. of our hydrants. In every case but one, a pleasure car was responsible for the accident. I have read opinions of other superintendents who seem to think that truck drivers are the particular damage-doers. I have greater respect for the ability of the average truck driver than for the man who drives his own car, for the simple reason that under Massachusetts laws, a man who receives compensation for driving must give a creditable demonstration of his ability before an inspector of the Highway Commission ere his license is granted. Others receive an operator's license upon their sworn statement that they understand the laws applying to motor vehicles and have operated a car at least 100 miles.

None of the hydrants damaged were located in business centers, and only one close to the intersection of two streets. The causes in two cases were laid to steering gear breaking; one, excessive speed; one, truck backing did not see hydrant; one, slippery street; others, unknown.

This is a comparatively small number of hydrants damaged when these figures are studied. At a point in the east section of the town, the average number of motor vehicles passing through daily from June 1 to November 1 of last year, between the hours of 10 A.M. and 8 P.M., was 7 500 on week days and 9 800 on Sundays. Between these hours last year a total of 949 776 motors passed. Taking into consideration the fact that we suffered 9 gasless Sundays last year, it may fairly be stated that under normal conditions over a million machines go through in a year between the hours of ten in the morning and eight in the evening.

The Massachusetts Highway Commission believes it to be the busiest thoroughfare in the state, and surpasses at times New York City's Fifth Avenue.

The cost of replacing a damaged hydrant averaged $50. This seemingly high cost has been due primarily to two causes. The hydrants without exception have been knocked over when payment of time-and-a-half or double time was necessary. The other cause is the fact that barrels cost $28.20 and stems $9.75.

We have had 14 barrels welded by the oxyacetylene process at a cost of from $12 to $15. Up to now none of these have been installed, although they have been tested under a pressure of over 100 lb. There is no question but that a saving of half the cost of a barrel will be made here.

In all but two cases, the barrel has snapped off at the flange. These two broke at the grade line.

Better policing may have been the reason that we have not been troubled along this line in the busy sections, but I believe it is because the average driver is more careful in business centers.

Several remedies for the prevention of hydrant damage have been set forth. Among them are:

1. Setting hydrant back from curb near building line.
2. Use of flush hydrants.
3. Use of bumper for protecting hydrant.

None of these appeals to me. In the first case, a hydrant set close to a building will be useless at a working fire in that building. And, further, a machine that has gathered momentum enough to jump the curb and strike a hydrant a foot from the edge has sufficient to go across the short distance of the sidewalk.

The second idea has been tried out and rejected in several of our northern cities. They are sometimes difficult to find under ice and snow. They must be salted regularly during cold weather to prevent freezing of the covers, with resulting disastrous delays. They are not as convenient for firemen as the post type.

The use of bumpers or other means of protection has, I understand, been used by some municipalities with varying success. It appears that if the bumpers are of the proper construction, heavy enough, and correctly located, they will be successful in the accomplishment of their purpose, to a limited extent. No obstruction may be placed directly in front of the hydrant without hampering the firemen in its use. They are unsightly objects for the most part.

From my own experience and that of some other superintendents, the best start is to use a strong-barreled hydrant. This will be somewhat effective. A coupé skidded on a wet road, one rainy day, in Milton, and struck a hydrant, canting it over to an

angle of 30 degrees. Of course, we supposed that the barrel had snapped off. When it was dug we were surprised to find no damage to the hydrant itself. The shock of the blow swung the hydrant around in the calked joint of the lateral. This would seem to indicate the advantage of sturdy construction in the hydrant barrel.

As regards the type of hydrant, there is more leeway. In a business where buildings are close to the street line, a hydrant that allows water to escape when the barrel is broken may result in suits for damage caused by the escaping water. In more sparsely settled sections a hydrant which permits the water to escape is an advantage, because it will more certainly be seen and reported.

We use the type with the sliding gate. This allows a certain amount of water to escape if the barrel breaks; not enough to cause any material damage, but, still, enough to be noticed. This hydrant may be equipped to prevent loss of water if desired.

The most satisfactory method of procedure, to my mind, is to use the slide-gate type of post hydrant, equipped with or without locking device, as conditions warrant, set in the tree lawn or near curb, at least 50 ft. from intersecting streets, and gate the branch, weld barrels when broken, and use no bumpers; or, if they are used, do not set them so close to the hydrant that they will hamper the use of hydrant by firemen when seconds count. There seems to be no adequate preventive. All we can do is let the accident happen, and get out of it in the cheapest way possible. What bothers me more than anything else is the collection of these repair bills. In some cases, the bill has been paid without question. In others, if the owner is not so inclined, he does not pay, and there the matter ends. The policy of the board has always been against bringing these cases to court, although in the opinion of our town counsel the owner of the machines is liable for damages.

This is only to start things. Let us hear experiences of other superintendents.

Mr. S. H. MacKenzie.* I should like to inquire what our friend uses as a locking device to hold the hydrant barrels in the thickly settled sections.

Mr. Heffernan. The device consists of a nut and jam-nut, placed between the top of the drip and bottom of the gate. When the hydrant is closed these nuts draw up against the bottom of the gate and prevent the gate from budging either up or down or any other way; that is, the top of the hydrant dome, packing plate, and so forth, can be taken off while the pressure is on, and the

* Engineer and Superintendent, Southington and Terryville Water Works, Southington, Conn.

gate will stay in its place. This is accomplished by absolutely locking the wedge so that the gate cannot move.

Mr. MacKenzie. What type of hydrant is that?

Mr. Heffernan. The Ludlow post hydrant.

President Killam. It seems to me this is a good, live subject. Most every one operating water works has more or less trouble with automobiles butting over hydrants. They tell me that if a little Ford runs into a hydrant it usually gets away, and you don't often find the machine.

Mr. Heffernan. I do not agree with you, Mr. Chairman, because what few hydrants we have had knocked over, in two or three cases have been by Ford machines.

If there is any gentleman here connected with water works who has had any experience with the collection of these bills, where a case has been brought to court, I should like to hear from him. We have several hundred dollars out, and we are trying to collect. We know that if we go into court it is going to cost us quite a little sum of money to fight the case, so that we are letting the matter slip.

I should like to mention one particular case which we will probably have to bring into court. There was an automobile owned by a well-known Boston man who was out driving and who told his chauffeur to leave him at a certain place, go and get his lunch, and come back for him in about fifteen minutes. Now, the chauffeur, instead of going back for his lunch, went on a joy ride, picked somebody up, and went in the opposite direction. The result was, at intersecting streets, while going at the rate, I should judge, of between 50 and 60 miles an hour, he came in collision with a car and the collision caused him to run into a hydrant and a standpipe and knock both of them over. We sent the bill for repairs to the owner of the car, and the owner of the car turned it over to the insurance people, who put up the argument that the car was stolen, that the orders given to the chauffeur were not obeyed, and that the chauffeur was responsible and not the insurance people. Now, that is a case that I think we have got to bring to court. It looks to me pretty fishy, to tell you the truth.

Mr. MacKenzie. I should like to inquire if welding pipe by acetylene gas is not successful. We had one split by frost and had it welded, but it cracked practically as fast as they welded it.

Mr. Heffernan. I had several hydrants during that severe cold winter that were headed by the frost, not at the top of the flange. And I have had those hydrants welded, and the job looks very good. I have only used the water pressure up to 130 or 135 lb. But as long as the welding job looks very good I am going

to install those hydrants. I am not going to pay $28 or $29 when I can have them welded for from $12 to $16. We gate all the hydrants as we put them in.

Mr. Frank J. Gifford.* I have had 4 or 5 hydrants welded, put under pressure, and they are all doing good work. And on a manufacturing plant in town I saw an 18-in. gate, split way around, and that was welded, put into service, and seemed to be working splendidly — no trouble at all. It may be that we have the man who is capable of doing the work, because he certainly is making a success of it.

I want to take exception to the President's remark about Ford cars, because about all my troubles have come from Ford cars — the Ford cars were not responsible, but the irresponsible drivers. We have collected about half of the bills sent out; the other half we are going to forget. It would cost us more to collect them than the bills are worth. We will let Milton collect them and get the custom established, and then we will go after them. We are a private company; Milton is not, — they have lots of money. In our case we shall forget the bills. In fact, one of the accidents was caused by a lawyer in town, and when I spoke to the clerk of our corporation, who is also a lawyer, he said, "For heaven's sake, forget it, never mind him; the abuse you will get from him will be worth more than the whole price of the hydrant." So that, after Milton gets the case on record so that it can be referred to, then perhaps we will go after them.

Mr. H. T. Gidley.† I agree with the last speaker that we have to forget those bills. That is the way it is in our case. I know of one case where a big coal truck backed into a hydrant and broke the hydrant. I sent a bill to the coal company and they said they did not own the truck. Come to find out, it was not one of their own trucks, it was one they had hired, and the fellow that was driving the truck was buying it on the instalment plan. He showed me how much he had paid for it — which was very little. He said, oh, yes, he would settle the bill; but that is the last I ever heard from him. I guess I will have to forget that.

Mr. George A. King.‡ I should like to inquire if the insurance companies will not settle those cases where they are interested, and for that reason is it worth while to send in a bill and get perhaps a quarter of it?

Mr. Gifford. I have had two settlements with the insurance companies.

* Superintendent, Water Works, Dedham, Mass.
† Superintendent, Water Works, Fairhaven, Mass.
‡ Superintendent, Water Works, Taunton, Mass.

Mr. W. A. MacKenzie.* We have had at least three settlements, I think, with the Travelers of Hartford, and no questions asked. They simply paid the actual cost of replacing the hydrant.

Mr. Heffernan. I should like to ask the superintendents about the average cost of repairing damaged hydrants; that is, if it was done by welding.

Mr. W. A. MacKenzie. In these cases we have settled for $40 to $65. In some cases we simply took the old bottom and put a new top on, and the actual cost was the labor.

Mr. Gifford. One peculiar case comes to my mind. I had one hydrant broken off, due to carelessness, pure and simple. The fellow that broke it got pretty fresh with the police officer and also with me. When I sent the bill in for repair to hydrant I included a bill for the estimated amount of water wasted through the hydrant, and collected the whole thing.

Mr. Francis H. Luce.† I might say that wherever we have a broken hydrant we always estimate the loss of water, figure it as high as we can, estimate as high as we can, and then figure it at the retail price, and then adjust the claim. It is very seldom that in the adjustment we collect as much as the estimated water loss amounts to.

Mr. Dow R. Gwinn.‡ From the experiences I have heard here this morning I should say that the brand of human nature in New England is very similar to what it is out in Indiana. If I can find the man that broke the hydrant and he is worth anything, we can usually get the money; but in a good many cases the fellow has spent all the money he had for the automobile and has none left to pay for the damage.

We had the same experience in welding hydrants that Mr. Heffernan spoke about. I think it has been very successful. Instead of paying about $13 or $14 for a new stock for the barrel, we were able to have it welded for about $5 or $6. We made quite a saving. I doubt if we have collected for over 40 per cent. of our broken hydrants. One man broke a hydrant; we found out his name and sent him a bill for it. He said, "Who is going to pay me for smashing up my radiator?" — and that is all the satisfaction we got out of him.

Mr. Frank L. Fuller.§ I should like to ask the gentleman if this welding can be done in place without taking out the hydrant.

Mr. Gwinn. Oh, no; we have to take the hydrant out.

* Superintendent, Water Works, and City Engineer, Wallingford, Conn.

† Superintendent, Water Works, Woodhaven, N. Y.

‡ President and Manager, Water Co., Terre Haute, Ind.

§ Civil Engineer, Boston, Mass.

Mr. Fuller. I should like to say that in Wellesley we have had a good many hydrants broken in one way or another by automobiles, and have found it very difficult to collect anything.

Mr. Stephen H. Taylor.* In New Bedford we have had comparatively little difficulty in collecting for our breaks. Once in a great while the fellow gets away if he is fortunate enough not to smash his car up, and we can't locate him. But I think in nine times out of ten where we locate him we get the money. The average cost of repairing the hydrants would be $40 or $50.

Mr. Gifford. Is there anybody present who has welded hydrants which have been used since that time for fire purposes, and, if so, was there any effect on the hydrant that was noticeable?

Mr. John Cullen.† We have several hydrants in my town that have been welded and have been subject to from 120 to 150 lb. pressure. We have not had any effect from any of them since; they all seem to stand the pressure.

President Killam. Have they been used for fire purposes since?

Mr. Cullen. Oh, yes; right along. In fact, they are working on the streets every day, building them and repairing hydrants, and we have a hose in use all day with pressure.

President Killam. The reason I mentioned the Ford car a few minutes ago was that our emergency truck responds to a sudden drop in the Arlington standpipe — we control the Arlington standpipe, which is directly connected with the Arlington distribution system, and this summer it has given the emergency truck very good exercise responding to calls from Arlington on account of sudden drops in the standpipe pressure. In every case it has been due to broken hydrants. During the last month three hydrants were broken, and in two out of the three cases there was not any auto there when we got there, but the police later found that they were both Ford cars. They had broken the hydrant off and gone along. If it is a larger car, the car is generally waiting for us, when we get there.

Repair of Inside Pipe Coating.

Mr. S. H. MacKenzie. We happened to have a car load of pipe come in, the other day, from a good, reliable foundry. On looking it over after it was unloaded, the coating seemed to have evaporated from the inside of the pipe. I was wondering whether anybody here had had experience in recoating pipes. I dislike very much to lay pipe in the condition that that is in; it would

* Assistant Superintendent, Water Works, New Bedford, Mass.
† Foreman, Water Works, Woonsocket, R. I.

be better for a gas company that wants uncoated pipe than for a water supply. In my opinion, the coating is a very important matter for water pipe. We believe that we ought to have our pipe well coated, as it will increase the life of it many years. I was wondering whether there was any material that any one had used or could recommend for recoating the inside of that pipe. We have used for some time a paint on couplings on the services, which we think is quite a help. A service that we took out several years ago showed that the pipe, where it was cut 2 or 3 in. back from the coupling, was practically as good as when it was put in several years before, but the coupling was practically stopped up. Since that time we have been painting our couplings inside, and I should think it would lengthen the life of the service by several years. I was wondering whether any one had used lead lined couplings and found that was an advantage, in preventing their rusting out. Hearing the discussion on painting standpipes, I thought possibly the red lead that was used on the inside of the standpipes might be a good material to use on the inside surface of the coupling. Perhaps it would be a better material than some other kinds of paint. We have been using an elastic paint, such as we use on the universal joints. The red lead, I take it, forms a union almost with the iron on the inside of the standpipes. It does not peel off like some kinds of paint, and that is what we want on wrought-iron pipe, while on the universal joints we want a more elastic paint which will give with the contraction and expansion of the pipe. I should like to know what others have used in that line.

Mr. Heffernan. In answer to the question about the couplings, we use in Milton the cement-lined pipe altogether, and use a lead-lined coupling, and I think it gives a perfect connection. There is no chance for the water to come in contact with the iron at all. On the main, right inside the cellar wall, we use brass fittings on the inside, and it gives a good service right into the meter. It allows no chance for corrosion.

Mr. S. H. MacKenzie. If that works satisfactorily for the cement-lined, I do not know why it would not on the wrought-iron pipe. One peculiar thing in regard to the brass couplings is that for a short distance it will oftentimes corrode. I am unable to account for that, but I know it is so.

Mr. Charles W. Sherman.* I wonder whether some of the trouble Mr. MacKenzie speaks of is not due to the corrosion on the cut end of the pipe rather than on the coupling itself. We all know that once you cut a galvanized pipe you will have a raw

* Of Metcalf & Eddy, Boston, Mass.

end, and that the rust and tuberculation will form there. With a good galvanized coupling I should not expect there would be any more rust on the inside of the coupling than on the pipe itself, but I should expect plenty of rust to form on the cut end. I do not see how a lead-lined coupling would improve that condition at all. As Mr. Heffernan says, lead-lined couplings have been used many years with success in connection with cement-lined pipe. I think they might be applied to galvanized pipe with success if something was done with the cut end, which would not be very difficult to do.

In regard to coating the inside of pipes in the field, I wish I could answer his question as to the practicability of red lead for this purpose. I do not see why it should not work very well, but I do not know of any case where it has been tried. We used to specify, and still do specify, various kinds of paint, asphalt veneer, or something of that sort, but for coating the places where the regular pipe coating is damaged in transit, or in handling, and how effective any of those things have been, I cannot answer. I wish Mr. McInnes were here, because I think he could probably tell us more than any other man I know of in the Association in regard to repainting or coating old pipes. He has had a good many old pipes in Boston which were never coated, and I think in some cases, at least, where the small pipes have been superseded those old pipes have been recleaned and relaid. But I am speaking from general inference now, and not from knowledged on that subject.

President Killam. Let me state what Mr. MacKenzie has asked. He said he had just received pipe from the foundry and certain places were not coated at all.

Mr. William R. Conard.* This is a matter which has been troubling several of the foundries, and as yet nobody has been able to explain it. The pipe has gone through in the regular way, been coated in the regular way, no signs of overheating, and the coating as the pipe passed over the scales and through the press would be in perfect condition. That pipe would not stay in the yard over two or three days when you would find, on examination, spots anywhere from a couple of square inches in area up to 25 or 30 in., where the coating had entirely disappeared, oxidized. There is no sign to indicate where it has gone or why it has gone; it has just dissolved into the air. It leaves the surface of the pipe absolutely clean; it does not indicate that there was anything on the pipe itself to cause the coating to leave in that manner.

Incidentally, I have in mind one foundry that has been pur-

* Material Inspection Engineer, Burlington, N. J.

chasing for years the tar for their coating from one particular gas plant and has never had any difficulty, when they accidentally ran into this condition. Immediately they got tar from other parties, another concern, but still that condition persists and nobody has been able to account for it as yet.

Some years ago there was a cargo of pipe shipped by barge from one of the Delaware River foundries to New Bedford, and they ran aground in the fog, staved a hole in the bottom of the barge, and sank. They lay there in the water for probably two weeks, when it was salvaged, brought up to New Bedford; but the action of the salt water was such that the coating was in very poor condition. The insurance companies were called in to make good, and after looking around for a while they found a quantity of, not asphaltum paint but a black paint called B.P.S. Structural No. 44 which is used for painting ship bottoms. They rigged up a wooden dipping tank; the pipes were all overhauled, cleaned and cold dipped. I do not recall what the expense was; of course it was rather high, because the paint was expensive. But I saw some of that pipe still lying in the pipe yard about four or five years afterwards, and as far as appearance went the coating was in just as good condition as when it was put on, although of course the pipe had never been used. It might be interesting to some of the water-works superintendents to investigate some such method of repairing the pipe that they may take up and want to clean and use again in that way.

President Killam. If you put some more cold paint over that first spot where the paint had disappeared at the foundry, would it adhere to the pipe without any trouble?

Mr. Conard. Yes, it should, where the spots are not too numerous or bad. As they term it, they touch them up, and the new paint they put on seems to hold all right. Most of the trouble seems to be within about 4 ft. of the spigot end on the outside, and in the immediate vicinity of the bell on the inside.

President Killam. About how long is it before that takes place?

Mr. Conard. You will find it the day following the pipe going through.

President Killam. In fact, it might be shipped sometimes before it was noticed?

Mr. Conard. Yes. In a case of rail shipment, where they are hurrying it forward, it will get away from you, because the pipe might go through and be put on board the cars that day. Of course, in the one instance I spoke of, the pipe was placed in the yard and had been lying there some weeks for water shipment to Providence.

President Killam. We have been getting some of it.

Mr. S. H. MacKenzie. I do not think it is entirely the coating that has been put on. I have in mind two foundries that make specials. As a rule, the specials that have come from one of the foundries have come well coated. They have been in the yard, some of them, a long time before the high prices came into effect. Practically all of the fittings that have come from the other foundry within the last two or three years, if not longer, can be immediately told by the looks of the coating. The coating is practically all coming off from the specials that come from one foundry, while on those that come from the other it is still in very good shape.

In recoating the pipe I think we want to be pretty sure we are using the right kind of material. I have in mind an experience I had ten or twelve years ago, before I took charge of the plant. Some pipe had been taken out and relaid, and before it was relaid it was dipped, and I think when they dipped it they must have used, perhaps, plain tar without pitch or any hardening material in it, because I used to have a call about once a week to come over and flush the line out, as they were getting the odor of tar, and the water was so strong of tar that they could not use it. I think that lasted for two or three summers at least. So that, before we experiment with recoating, I think we want to be pretty sure that we are getting a material that will stick to the pipe, harden, and not cause a taste in the water.

In regard to the galvanized couplings that Mr. Sherman spoke about, a galvanized coupling is no different from a black coupling on the inside, it is only galvanized on the outside. It has no coating on the threads, and as a rule the best of the pipe does not get coated on the couplings. They leave from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch of the raw thread. If the couplings are painted when you put the pipe together, as a rule, the raw end of the pipe would be covered by that paint. But if they just paint the pipe when they put it together, it does not cover the $\frac{1}{2}$ to $\frac{3}{4}$ in. of raw thread. The way we have done is to paint the coupling on which the paint has become hardened, and paint the pipe also at the same time, and that paint would push ahead and cover the raw ends of the pipe.

Mr. W. C. Hawley.* We have taken up quite a little pipe, burned out the joints and repainted the ends of the pipe, and that pipe has been stored in the yard for some time, some of it put in immediately. So far as I know, we have had excellent results.

Mr. George A. King. Mr. MacKenzie referred to the trouble at the sidewalk cock. I would suggest that that is possibly elec-

* Engineer and General Superintendent, Penn. Water Co., Wilkinsburg, Penn.

trolytic action. I think the paper by Mr. Weston which we had some nine years ago made some surprising statements in relation to that action due to proximity of different metals.

President Killam. In touching up pipe, the Metropolitan Water Works at Boston has always used until recently the pipe gun, which has been very successful. I have had occasion to examine considerable pipe that has been in eight to ten years, and the coating was very good. Whenever an opportunity has occurred I have been experimenting. I have some pipe now coated with paraffine inside — this is 125-degree paraffine — and some with different combinations of red lead. The red lead has been in use about five years, and I had a chance to examine it last year. It did not appear that there had been any wear or tear or any tubercles form on the red lead. While the cost, of course, is considerably more than ordinary pipe paint, I think in the end it is going to pay us on large pipe lines to adopt something of that kind, either at the foundry or in the yards, or after the pipe is laid, on account of the loss of head in pipe lines. I have in mind one 48-in. line in which the flow has decreased in fifteen years over 20 per cent. on account of the tubercles. Of course that is a pretty large figure, but the cost of relaying these lines or new lines is so great that I think it is going to pay us to consider the coating that will stand up in years to come for the interior of the pipe line.

Mr. S. H. MacKenzie. What have you found the best way to clean the pipe before applying the coating? For instance, if I wish to recoat this car load of pipe, what would be the best way to clean it to make sure the coat would stay on? Would you thoroughly clean and then clean with gasoline?

President Killam. I have never tried that method. We have used scrapers and wire brushes. That brings up another question. On the 48-in. line we recently cleaned about 500 ft. in place, using oak and chestnut scrapers, so that there would not be any hard substance next to the pipe to injure what coating there was left, and then that was thoroughly brushed out with wire brushes, then washed out as far as we could to get what dust there was left before we applied the coating. I am under the impression that you can't be too thorough in your cleaning before applying coating to any pipe. That applies to pipe also that has stood in the yard and just simply rusted. If you paint over that rust with ordinary pipe paint, in a year or two the rust will come through; whereas if the rust is thoroughly cleaned from the pipe and the coat applied, it will generally last.

Mr. Sherman. It seems to me that your metropolitan experience of scraping and wire-brushing the inside of the pipe is

not going to help the ordinary small water-works man very much whose largest pipe is 12 in. in diameter. The problem of properly cleaning the pipe before applying the coating, when the size does not exceed, say, 16 in., is rather a serious one. It may be that a wire brush on the end of a pole, something like a chimney-sweep's brush, would give fairly satisfactory results. At the moment I can't think of anything better than that to try.

President Killam. Of course our experience does not apply to the small water-works man, but we have small pipes down to 12 in.

Mr. Sherman. You do not clean them that way, do you?

President Killam. No, not by going inside. I went in one once, some years ago, and I came near not getting out, so that I haven't been in since. But in cleaning the 12-in. pipe in the yard, we use a long pole with a wire brush in the center, two men operating it, one on each end, and they sweep through and cover the whole pipe, and then follow that with what we call a screen brush, which takes the dust out. The painting is usually done by a long pole with a brush on the end.

Mr. Fuller. I do not understand, Mr. President, just how you apply the paint. With a brush at the end of the pole?

President Killam. Yes, with a brush, the same as used in Massachusetts or eastern New England for moth work. A small brush on the end of a long pole.

Mr. Edward D. Eldredge.* On the cement-lined pipe, I have used that with considerable success. I also cement-line couplings. Where wrought-iron pipe is run, I put the coupling on for good and line that at the same time, and afterwards, the next day or the second day, trim out a few threads where the next pipe will enter, and that which enters will butt up against the cement in the coupling. There is no trouble with it at all.

In the use of galvanized pipe, I have cement-lined the couplings. Reverse the coupling, take it up and cement-line it by hand, just the coupling itself, covering all the bare end threads. Then after the cement is properly set, trim out the few entering threads again. That makes a successful job. It prolongs the quality of the galvanized pipe very considerably. I consider the ideal pipe is cast-iron, cement-lined.

Mr. Fuller. For service pipe?

Mr. Eldredge. Yes.

Mr. George A. Benjamin.† Is there anybody here who has had experience with hot water flowing back from the service pipes into the mains? I notice there are services where they have hot-

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* Superintendent, Water Works, Onset, Mass.

† Manager, Water Co., Castine, Me.

water pipes, and those services rust quicker than others. That has been my experience. I have thought of obliging those people to put on check-valves in the cellar walls to prevent the hot water from flowing back.

Mr. Heffernan. Some years ago — I think it was a year or two years ago — that same subject was taken up at one of the meetings, regarding pressure boilers being installed in the basement close to the meter. I know in one case in Milton a boiler was installed, and the blow-off was set, I think, at 105 lb., and it stuck, and blew out their service, damaging our meter. The disk of the meter was expanded by the hot water, and so forth, so I got in touch with the plumber who installed the plumbing in the house, and we went over the subject, and put in two check-valves, one opening with the pressure and one against; that is, a check in the one flowing back — to prevent excessive pressure if the boiler got hot — so that it would go out into the street instead of going into the meter. There were two or three meters damaged, and that was the only way we could do it. But since that time we have had a rule introduced that vacuum relief valves should be put on all services, so that we do not get any trouble in those particular services. The only remedy we had was to put in a by-pass and send it back into the street mains.

Mr. Benjamin. The reason I raised the question was on account of rusting of the fittings of the pipe. My experience with the plant I have now is that that is taken up in the service pipes. When I say that the service pipes do not rust, the plumbers come right back at me and say, "Oh, yes, they do"; and then they will refer to some case of that kind where they have had hot-water boilers. That seems to be the difficulty that I am having now.

Mr. Gidley. I have not run across that in services, but in a case where there were some cheap houses built to sell they put in galvanized boilers for their hot water, and did not own those houses but a very short time before they telephoned to us that our water was terrible and was spoiling all the clothes that they washed, their plumbing fixtures, and everything. I have no doubt but what the hot water caused them to rust quicker than they would have done otherwise.

STANDARD HOSE COUPLINGS.

BY F. M. GRISWOLD.*

Some of the members will remember the fact that it was thirteen or fourteen years ago when the matter of standard hose couplings was placed before this Association by a committee of which I was then the chairman. I have retained my very particular personal interest in the subject, although I have lost my official connection with it, and I feel that I ought to transmit to you now some information in relation to how the matters are progressing towards accomplishment in the standardization of hose couplings.

The first and most important element now is the fact that the National Screw Thread Commission, appointed by the Government under an Act of Congress and which is practically under the charge of the Bureau of Standards, has accepted the same standard specifications which have been adopted by this and many other associations. We have been striving for a number of years to find or devise a tool which would enable us to convert a non-standard coupling to interchange with the standard coupling, whether it is of lesser diameter than $3\frac{1}{16}$ or in excess of $3\frac{1}{16}$. We have now completed, put into operation, and demonstrated the feasibility of the tools.

Couplings which were less than 3 in. inside diameter have been enlarged by the expander and the threads, whether they be 8 or 7 or $7\frac{1}{2}$, have been re-cut to make them fit the standard. Likewise in relation to larger sizes we have been able to reduce them very readily by this new set of tools. And we have changed the conditions in quite a number of places where formerly some of the couplings were under size and in others over size. We have demonstrated the feasibility to such an extent that the state fire marshal in Indiana proposes to purchase several sets of these tools, and undertake the complete standardization of all non-standard couplings now in use within that state, under the supervision of his engineers, to each of whom will be assigned a separate district of operation.

There has been more or less criticism among the people whom we have approached on this subject. I am very glad to say that the Indianapolis water-works people have decided that when we have the tools and will come on the ground they will be glad to assist us in standardizing their couplings.

I tell you this to show how continued propaganda will bring about a desired result. I was told that if I did anything in twenty years in reference to securing standardization I would be entitled to great credit. I think that inside of three months from the time I was appointed chairman of the

* General Inspector, Home Insurance Company, New York.

Committee on Standardized Couplings I had the approval of the New England Water Works Association, which approval was supplemented by like action by some fourteen other public organizations of national importance and authority in relation to water supply and fire extinguishment, and finally of the Bureau of Standards, which has adopted exactly the standard you have and included its specifications in its last report. I have here some photographs of the tools in operation, which may be of interest to those who would like to look at them. We will probably come to you by and by and say, Here are the tools and we will show you how you can change your couplings with very little expense and with no trouble. In fact, with two men you can change twenty-five to fifty hydrants, two outlets, in a day. The expansion of the undersized couplings in place is a very simple thing, and we have had so far but a very small per cent. of them injured in the least. Several of them which did break showed a deterioration in the casting.

(*By letter.*) I assume that it will prove of interest to the organization to be informed as to the progress being made in that direction as a result of recent field work in the conversion of non-standard equipment formerly in service in the towns of Lambertville and High Bridge, N. J., and New Hope, Pa., and therefore beg to submit for your information the following statement as summarized from the report of Mr. J. H. Howland, engineer of the National Board of Fire Underwriters, who, assisted by Mr. G. W. Carpenter, representing the Greenfield Tap and Die Corporation, of Greenfield, Mass., very successfully converted the hose and hydrant equipment of the towns named, using in the work a very complete set of taps, dies, expanders, and other tools produced by the Greenfield corporation.

The report referred to is dated May 28, 1919, and may be briefed as below:

"During the past two weeks and pursuant to the receipt of official authorizations, the writer, with the valued assistance and coöperation of Mr. G. W. Carpenter of the Greenfield Tap and Die Corporation, converted to the National Standard the threads on all hose couplings, hydrant nipples and caps and play pipes, special fittings and connections to fire apparatus or equipment, in the municipalities and protected manufacturing concerns of High Bridge and Lambertville, N. J., and New Hope, Pa."

High Bridge, N. J. (May 12 to 20 inclusive):

"The original threads having an outside diameter of 3 in. and a pitch of 8 threads to the inch, were made to conform with the National Standard. The fittings so converted were as follows:

"(1) At the two borough fire stations — 30 pairs of hose couplings, 7 play pipes, 4 hydrant hose gates, and 2 chemical connections.

"(2) At the Taylor-Wharton Iron and Steel Plant — 53 pairs of hose couplings, 14 hydrant hose gates, 11 play pipes, 10 hydrant caps, and 16 hydrant nipples.

"(3) A total of 103 nipples and a like number of caps on all of the borough hydrants."

Lambertville and New Hope:

"The threads in these municipalities and the local manufacturing plants having originally an outside diameter of $3\frac{1}{16}$ in. and a pitch of 8 threads to the inch, it was only necessary to re-chase the threads with the standard tap and die to change the pitch. This work was accomplished easily, and except for slight delays in finding the thread of male fittings (having pitch diameter slightly greater than Standard) with the standard die, without any delays."

The threaded fittings which were made Standard included:

"(4) At the three Lambertville fire stations a total of 56 pairs of hose couplings, 7 play pipes, 7 chemical or pump connections, 2 siameses or Y's, 5 double males or male and female specials, and 2 suction reducers.

"(5) A total of 80 hydrant nipples on 40 Lambertville street hydrants. The caps on these hydrants were not altered, as they made an excellent fit with the re-chased threads on the nipples.

"(6) At the plant of the N. J. Rubber Company, 14 pairs of hose couplings, 8 hydrant nipples, 2 fire pump connections, and 5 play pipes.

"(7) In the New Hope fire station, 19 pairs of hose couplings, 5 play pipes, and 2 steamer connections.

"(8) At the plant of the Universal Paper Bag Company, 6 hydrant nipples, 8 pairs of hose couplings, and 2 play pipes.

"(9) At the Union Paper Mill Manufacturing Company, 6 hydrant outlets, 11 pairs of hose couplings, 4 play pipes, and 5 fire pump connections.

"The above work of standardization was done in $2\frac{1}{2}$ days by 3 men, with one additional helper to handle hose a portion of the time. From the results obtained it is estimated that 2 experienced men can standardize threads, having an outside diameter of $3\frac{1}{16}$ in. and either 7 or 8 threads to the inch, on 125 pairs of hose couplings, or on 75 two-outlet street hydrants in a day."

During the operations above indicated there was a surprisingly small number of instances in which hydrant nipples and male end couplings were fractured during the process of expanding such as were of undersize, such fractures being entirely due to thinness of the shells or to inferior grade of metal composing the castings. Taking the work of conversion as a whole, the results are particularly gratifying from a mechanical viewpoint, and appear to warrant the acceptance of the conclusions reached by Mr. Howland that —

"It is believed that with the suggested alterations and improvements made in the complete kit of tools, the work of standardization in the field will prove thoroughly practicable and in every way satisfactory.

"From the results obtained in this first field work it is believed that we have sufficient data to overcome any difficulties likely to be met with in the work of standardizing undersized fittings down to an outside diameter of $2\frac{31}{32}$ in. It would perhaps be advisable before undertaking to standardize fittings in a large number of municipalities, to obtain an authorization and standardize some city or town having oversized fittings with outside diameters of $3\frac{5}{64}$ or $3\frac{3}{32}$ in."

In presenting to you this statement of progress I feel assured that we

are all warranted in feeling justified in our purpose to bring about this much needed condition of harmonizing our private and public fire-fighting utilities to a uniform specification, and gratefully give appreciative recognition to the consistent and continued support given by the N. E. W. W. Association in forwarding this worthy endeavor to assured accomplishment.

Quoting from Mr. Howland, " You will note that we are rapidly approaching a stage of development where our long-enduring though cherished movement is about to ' go over the top,' " and I trust that the accomplishment of purpose as above indicated may prove as much of an inspiration to further effort by your Association as it certainly does to the writer.

Mr. Chase. Do the nipples have to be taken out of the hydrants to do the work?

Mr. Griswold. No; it is not necessary to remove them.

PROCEEDINGS.

DECEMBER MEETING.

HOTEL BRUNSWICK,
BOSTON, MASS., December 10, 1919.

The President, Mr. Samuel E. Killam, in the chair.

Elected for active membership, William A. Nial, construction engineer, Troy, N. Y.

Col. Richard K. Hale gave an interesting account of his experiences as an officer of the A. E. F. during the World War.

The report of Committee on Budget for 1920 was read by Mr. George A. Carpenter, chairman. (Printed in December JOURNAL.)

Discussion of Mr. Creed W. Fulton's paper, "Modern Pumps for Small Water Works," by Mr. A. O. Doane and Mr. Frank L. Fuller.

Mr. Frank J. Gifford, superintendent Dedham Water Company, Dedham, Mass., read a paper entitled "Description of Motor-Driven Portable Thawing Machine Mounted on Truck." Messrs. J. M. Diven, Reeves J. Newsom, Frank L. Fuller, Morrison Merrill, Wm. N. Bonner, J. A. Hoy, David A. Heffernan, George McKay, Jr., and H. V. Macksey took part in the discussion.

The President then introduced Mr. C. J. G. Haas of the H. Mueller Manufacturing Company, who urged upon the Association the advisability of appointing a committee of the Association to confer with a committee of the Brass Manufacturers Association, with a view to standardizing brass goods.

On motion of Mr. J. M. Diven, seconded by Mr. Frank L. Fuller, it was voted to appoint a committee of three to act in conjunction with a committee of the American Water Works Association with the National Association of Brass Manufacturers, in the consideration of this matter.

Adjourned.

ANNUAL MEETING.

HOTEL BRUNSWICK, BOSTON, MASS.,
January 14, 1920.

The President, Mr. Samuel E. Killam, in the chair.

The following, properly endorsed and recommended by the Executive Committee, were duly elected active members: Robert Gardner, Lowell, Mass., superintendent Lowell Water Works; Arthur H. Pratt, Newark, N. J., designing engineer North Jersey District Water Supply Company;

Chen Tan, Tientsin, China, assistant field engineer, Grand Canal Improvement Work, China, — three.

In connection with the history of the 26th Engineers which is soon to be published as a number of the New England Water Works Journal, the President introduced Lieut.-Col. F. Scheidenhelm, who told of the activities of the 26th Engineers in France in providing water supply for the troops.

Mr. John M. Goodell, editor of the American Water Works Association *Journal*, gave a short talk.

Mr. Charles W. Sherman. Mr. President, the last few meetings, those of us who have been coming to these meetings for a number of years have, with much regret, missed a face that has been familiar to us at a great majority of the meetings ever since this Association was formed. That is the face of Mr. Robert C. P. Coggeshall, although I probably did not need to mention the name to the older members. Mr. Coggeshall's health is not what it was, and it is difficult for him to get to our meetings. I know that he wishes he could come, but I doubt if he wishes it any more than most of us wish he could be with us. I want at this time to offer a resolution of recognition and appreciation to be sent to Mr. Coggeshall:

"The New England Water Works Association, in annual meeting assembled, records its grateful appreciation of the valuable services rendered to it by Robert C. P. Coggeshall throughout the life of the Association, and sends him its cordial greetings and best wishes for 1920."

(The motion was duly seconded and unanimously carried by a rising vote.)

The President. We have recently lost by death one of our active honorary members. I refer to Frederic P. Stearns, who has been the father of our water supply of this district, and the father of a number of other engineering projects. A committee has been appointed and will report later on the death of Mr. Stearns.

Reports of Committees.

Collection and Standardization of Rainfall and Run-Off Measurements.

Mr. William T. Barnes, representing the committee, reported that no progress had been made since the convention at Albany.

It was decided at the joint meeting with the committee of the Boston Society of Engineers, that the Boston society should confine its work largely to rainfall and run-off statistics bearing upon water power, leaving to the committee of this Association the collection of data bearing upon water works.

Mr. Barnes emphasized the importance of the members sending in

all available data, and stated that it was the purpose to have this data collected once in three or four years, and suggests that the Association, through committees, have it brought up to date from time to time. He further stated that Mr. Goodnough, who brought the data down to 1912, had kindly brought this up to near the present date, and that it will soon be ready for publication.

Revision of Constitution and By-Laws.

Mr. Henry V. Macksey said that progress has been made, but that no definite report is ready at this time.

Standard Specifications for Cast-Iron Pipe and Special Castings.

Mr. Frank A. McInnes stated that it had been impracticable to make much progress during the war upon this subject, and that the cast-iron pipe business was still in such shape that it had not been practicable to go into the matter.

Definite results are hoped for during the coming winter.

Standard Specifications for Fire Hydrants.

Mr. H. O. Lacount by letter stated that the manufacturers had promised to give the information desired, but as yet data had not been received.

The committee appreciates the importance of finishing this work without further delay, and expects to be able to submit final report within the next few months.

Report of Committee on Statistics of Water-Purification Plants.

December 20, 1919.

To the President and Members of the
New England Water Works Association:

Introduction.

Gentlemen, — The preliminary report of the Committee on Standard Statistics for water-purification plants was read on September 9, 1914, and published in the Journal, Volume XXVIII, No. 3, pp. 230–237. The presentation of this report was followed by several meetings of the committee, and subsequently by the presentation of the final report on January 13, 1915.

On January 13, 1915, you continued the committee, at its request, to observe the trial of these statistical forms in practice. The blank statistical forms which the committee submitted with its final report were sent to a large number of plants represented in the Association, and many of these responded by using them to present their statistics. The committee has several sets of these records on file.

The World War interfered with the work of the committee, and hitherto it has been unable to present the results of the trial of the forms in practice and its final recommendations, although it has presented verbal reports of progress at the annual meetings of 1916, 1917, and 1918. The criticisms of those who have used the forms, and further study of the problem by your committee, have resulted in some changes and improvements which will make the forms usable by a larger number of plants. Exclusive of typographical corrections, the changes are as follows:

Table 1.

Add the words " before Treatment " to title. Omit the " Permanent Hardness " column, and substitute a blank column to be used for hardness, manganese, lead, copper, sulphate, or other determined constituents. Change the next to the last column to read " Total Microscopic Organisms per c.c.," and change its note to read, " Mention important genera; does not include amorphous matter."

Table 2.

Add footnote, " For certain waters the above ranges should be subdivided to read: 0—5; 6—10; 11—15; etc."

Table 3.

For certain waters the above ranges should be subdivided to read:
0—25; 26—50; 51—75; 76—100; etc.

Substitute dotted line for " Gelatine," because the use of some other medium is necessary at certain plants.

Table 4.

Omit the " Permanent Hardness " column, and substitute blank column as in Table 1. For " Iron," substitute " Total Iron."

Table 6.

Add footnote, " For some waters the above ranges should be subdivided as follows: 0—5; 6—10; 11—15; etc."

Table 7.

Omit abbreviations from tables, such as "No.," "+," "—," etc., so that headings may read " Number of Positive Results," " Per Cent. of Positive Results," " Per Cent. of Time," etc.

*Table 9.**

Add " Feet " to the " Average Loss of Head " column.

*Table 10.**

For " Total Sand Scraped," substitute " Total Sand Removed by Scraping," and make subcolumn read " Depth in Inches." Make next column read " Number of Filters to Which Sand was Restored " instead of " is Restored."

Under certain columns indicated on the table, add the following footnote:

" In larger plants the maximum and minimum results should be given in addition to the average."

*Table 12.**

Change arrangement and form to read as follows:

* This table given in original report and published in advance copies of same, but not in JOURNAL.

TABLE 12.

WATER PURIFICATION WORKS IN CITY OR TOWN OF. . . . .

Annual Cost of Operation and Fixed Charges per Million Gallons of Water Delivered to Mains for the Year 19 .

COST OF OPERATION AND MAINTENANCE.	Year.	Previous Years.	
	19	19	19
A. *Operation.*			
Pumping*			
Chemicals and Treatment			
Chemicals and Treatment			
Chemicals and Treatment			
Supervision			
Laboratory Salaries			
Laboratory Supplies			
Attendance			
Watchmen			
Cleaning Basins			
Sand Raking			
Sand Scraping			
Sand Washing			
Sand Restoring			
Total Sand Cost			
Wash Water†			
Heating			
Lighting			
Telephone			
Stable and Garage			
Miscellaneous			
Total Cost of Operation per Annum			
Ditto, per million gallons			
B. *Maintenance.*			
New Sand			
Buildings and Grounds			
Repairs			
Miscellaneous			
Total Cost of Maintenance per Annum			
Ditto, per Million Gallons			
Total Cost of Operation and Maintenance per Annum			
Total Cost of Operation and Maintenance per Million Gallons			
Total Fixed Charges per Annum			
Total Fixed Charges per Million Gallons			
Total Cost of Purified Water per Annum			
Total Cost of Purified Water per Million Gallons			

* Pumping raw water, or additional cost of pumping water because of purification.
† Including cost of pumping wash water.

All Tables.

Add blank space for name of City, Town, or Company.

Omit abbreviations as far as practicable, particularly "No." and "+." Correct punctuation, and in footings substitute a dotted line for right lines in spaces not to be used. Also make the line between each table and its footing a double one.

Examples.

Examples showing the use of each table are appended to this report.

Other Tables.

Your committee's report covers statistical forms for monthly and yearly results only. Most plants should also provide themselves with a monthly record sheet to be used to collect the data for determining the average monthly results. Because of the great variation in plants, it is impracticable for a committee to devise a form which could be used by all. Therefore the management of each plant is urged to prepare its own form. The form used at Little Falls, N. J., is given as an example.

ENGINEERING SUMMARY OF DAILY RESULTS

THE MONTCLAIR WATER CO. FILTRATION WORKS

................SUPT. .... LITTLE FALLS, N.J.

Day of Month	Plant in Operation (Hours)	Number of Service Hours	Length of Runs (Hours)	Filtered Water (Million Gallons)				Average Loss of Head		Washing Records				Chemicals Applied											
				Delivered to Mains	Wash Water	Per Acre per Day		Initial	Final	Number of Washes	Average Minutes		Per Cent Wash Water	Sulphate of Alumina			Chlorine			Lime			Soda		
						Yield	Rate	Feet	Feet		Air	Water		Pounds per Day	Pounds per Mil. Gals.	Parts per Million	Pounds per Day	Pounds per Mil. Gals.	Parts per Million	Pounds per Day	Pounds per Mil. Gals.	Parts per Million	Pounds per Day	Pounds per Mil. Gals.	Parts per Million
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ANALYTICAL SUMMARY OF DAILY RESULTS

THE MONTCLAIR WATER CO. FILTRATION WORKS

................SUPT. .... LITTLE FALLS, N.J.

Day of Month	Chemical Results (Parts per Million)																		Bacteria per Cu. Cm.									B. Coli				Micro Organism Standard Units per C.C.
	Alkalinity		Free Carbonic Acid		Dissolved Oxygen		Turbidities					Color							Agar		Gelatine @ 20°C.							Nº Positive				
							River(3)			Del(3)		River (3)				Del.(3)			37°C.		River (3)					Del(3)		River(3)		Del (3)		
	R (3)	D (3)	R (1)	D (1)	R (1)	D (1)	0-10	11-25	26-50	0	1-5	11-25	26-50	51-100	Over 100	0-5	6-10	Over 10	R (1)	D (1)	0-100	110-300	350-1000	1100-10,000	Over 10,000	0-10	11-25	0.1cc (2)	1.cc (1)	1cc (2)	10cc (1)	River
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CHEMICAL ANALYSIS ON............ {River Water (Cl ....) (T Hard......) (Incaust.....) (Iron.....) (Oxy. Cons .....)
{Delivered " (" ....) (" ......) (" .....) (" .....) (" .....)

In a large plant it is often desirable to summarize certain results which would be significant to the average citizen, for presentation in the annual report of the operation of the plant. Here, again, it is impracticable to devise a form which would fit all plants. Therefore the following list of significant data is given as a guide:

Summary of Principal Data.

(Mechanical Filter Plant.)

Gallons Filtered	Total per Annum Average Daily Maximum per Day Minimum per Day
Rate of Filtration (Million Gallons per Acre per Day)	Average Maximum Minimum
Average Turbidity of Water	Unfiltered Water Filtered Water
Average Color of Water	Unfiltered Water Filtered Water
Average Alkalinity of Water	Unfiltered Water Filtered Water
Rate of Application of Chemicals. (Give Kinds.)	Average Maximum
Average Percentage of Wash Water	
Average, Maximum and Minimum Numbers of Bacteria per c.c.	Unfiltered Water Filtered Water
B. coli Index	Unfiltered Water Filtered Water
Total Iron	Unfiltered Water Filtered Water
Total Cost of Operation and Maintenance per Million Gallons	
Total Cost of Water per Million Gallons	

Recommendations.

Your committee feels that the forms as revised are suitable for adoption by the Association and for general use in water-works plants. We therefore recommend that they be printed and sold singly or in sets at a price sufficient to cover their cost. We also recommend that each set should include a copy of the 1915 report of the committee, revised to agree with subsequent reports of the committee. The committee also asks that it be discharged as soon as the first printing of the forms and of the revised report has been made.

Respectfully submitted,

GEORGE C. WHIPPLE, *Chairman.*
FRANCIS D. WEST.
ELBERT E. LOCHRIDGE.
FRANK W. GREEN.
ROBERT SPURR WESTON, *Secretary.*

Note. — Forms used by various water works, submitted with this report, are on file at office of New England Water Works Association.

Leakage of Pipe Joints.

President Killam stated that no progress report was available, due to Mr. Barbour's illness.

Standard Specifications for Water Meters.

Mr. Charles W. Sherman made progress report, of which the most important item was the appointment of a committee by the American Water Works Association to consider this subject, and to act jointly with the committee of this Association.

Proposed Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions.

Mr. Frank A. McInnes reports no definite action since the annual meeting. He reminds the Association, however, that it is very important that the members furnish information relative to this subject to the committee.

Mr. McInnes said that the committee had published in its report a list of some thirty cities which had been graded under the schedule, and has asked for comments and criticisms. The committee wished to repeat this request.

A National Water Law.

Mr. Caleb M. Saville. This committee has communicated with the Water Service Committee of the Engineering Council, and is waiting for report from them, which will be turned over to the Association later.

Extension of Mains.

Mr. Caleb M. Saville. No report is ready at this time.

National Department of Public Works.

Mr. Henry V. Macksey states that there is really nothing further to report beyond that already sent in, recommending that the individual members give the Department of Public Works such support as they could, and that the Association, as a body, should not formally support the movement, because it was unable to give the financial backing which might be necessary.

President Killam stated that a meeting was held yesterday and to-day in Washington on this subject, Mr. Metcalf representing this Association, who will undoubtedly make a report at the next meeting of the Association. He further stated that Professor Swain had been invited to talk on the National Department at the February meeting.

Mr. Charles W. Sherman moved that Committee on Public Works be discharged, which was duly carried.

Reports of the other committees were accepted as reports of progress, and committees continued.

Report of the Secretary.

January 2, 1920.

Mr. President and Gentlemen of the New England Water Works Association, — The Secretary submits herewith the following report of the changes in membership during the past year, and the general condition of the Association.

The present membership is 899, constituted as follows: 12 Honorary, 810 Active, and 77 Associate Members, there being a net loss for the year of 6. The detailed changes are as follows:

MEMBERSHIP.

January 1, 1919.	Honorary Members	13			
	Died	1			
		—			12
January 1, 1919.	Total Members		815		
	Withdrawals:				
	Resigned	33			
	Dropped	18			
	Died	8			
		—	59		
			—	756	
	Initiations:				
	February	4			
	March	6			
	June	9			
	September — October	19			
	November	9			
	December	1			
		—		48	
	Reinstated:				
	Member dropped in 1917	1			
	Members dropped in 1918	3			
		—	4		
	Elected in 1918, qualified 1919,		2		
			—	6	
				—	810
January 1, 1919.	Total Associates		77		
	Withdrawals:				
	Resigned	4			
	Dropped	2			
		—	6		
			—	71	
	Initiations:				
	January	1			
	September	2			
		—	3		
	Reinstated:				
	Associates resigned in 1919		3		
			—	6	
				—	77
January 1, 1920.	Total membership				899
January 1, 1919.	Total membership				905
Net loss					6

Receipts for 1919.

Initiation fees			$234.00
Annual dues:			
Members	$3 231.14		
Associates	1 440.00		
		$4 671.14	
Fractional dues:			
Members	$35.00		
Associates	40.00		
		75.00	
Past dues		35.00	
Total dues			4 781.14
Advertising			1 903.75
Subscriptions			261.00
JOURNALS			129.00
Sundries			835.16
Total receipts			$8 144.05

There is due the Association:	
Advertisements	$60.00
JOURNALS	2.00
Meter rate sheets	1.00
Total	$63.00

Respectfully submitted,

WILLARD KENT, *Secretary.*

REPORT OF THE TREASURER.

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report:

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$186.40
Initiation fees	$234.00	
Dues	4 781.14	
Total received from members		5 015.14
JOURNAL:		
Advertisements	$1 903.75	
Subscriptions	261.00	
JOURNALS	129.00	
Sale of reprints	39.20	
Total received from JOURNAL		2 332.95

Miscellaneous Receipts:		
Sale of "Pipe Specifications"	$18.90	
Dinners	658.50	
Certificates of membership	12.00	
Buttons	.75	
Meter rate sheets	2.68	
June excursion	46.84	
Albany pictures	48.00	
Index	1.00	
Total miscellaneous receipts		788.67
Total receipts		$8 323.16

Expenditures.

JOURNAL:		
Advertising agent's commission	$122.50	
Printing	1 820.00	
Editor's salary	300.00	
Editor's expense	23.71	
Reporting	347.41	
Reprints	169.50	
Envelopes and postage	50.70	
		$2 833.82
Office:		
Secretary's salary	$200.00	
Secretary's expense	20.60	
Assistant to Secretary's salary	1 080.00	
Assistant to Secretary's expense	159.19	
Substitute Assistant to Secretary	68.67	
Rent	687.50	
Printing, stationery, and postage	374.56	
Membership lists	283.67	
		2 874.19
Meetings and Committees:		
Stereopticon	$70.30	
Dinners	681.10	
Music	29.50	
Printing, stationery, and postage	328.75	
Badges	67.50	
Clerk at Albany convention	52.50	
		1 229.65
Treasurer's salary and bond		67.50
Certificates of membership		2.40
Miscellaneous		110.11
Dues of members in service		192.00
Flowers		10.00
Income tax		6.49
Engraving Brackett medal and cases		8.50
		$7 334.66

LEWIS M. BANCROFT, *Treasurer*,

In account with the New England Water Works Association.

RECEIPTS.			EXPENDITURES.		
1919.			Bills paid		$7 334.66
Jan. 1. Balance on hand		$2 957.03	BALANCE ON HAND.		
Received of Willard Kent, Secretary		8 144.05	People's Savings Bank	$2 000.00	
Interest on bonds and deposits		179.11	Mechanics Savings Bank	481.65	
			First National Bank	435.55	
			Liberty Trust Company	1 028.33	
					3 945.53
		$11 280.19			$11 280.19

ASSETS AND LIABILITIES.

ASSETS			LIABILITIES.	
Cash balance in banks		$3 945.53	Accounts payable	$0.00
Bonds Nos. 2642 and 2644 Lake Shore & Michigan Southern R. R. 4s, due 5-1-1931.			Surplus	5 863.53
Book value	$1 815.00			
November coupons	40.00	1 855.00		
Accounts receivable:				
Advertising	60.00			
JOURNALS	2.00			
Meter rate sheets	1.00			
		63.00		
		$5 863.53		$5 863.53

BOSTON, MASS., January 12, 1920.

LEWIS M. BANCROFT, *Treasurer*.

Report of Auditing Committee.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers. The Treasurer has also accounted to us for the investments and cash on hand, as submitted in the above report.

GEORGE A. CARPENTER,
EDWIN L. PRIDE,
FRANK A. MARSTON,
Finance Committee.

The President. It would be unfair to the incoming administration to allow the impression to go out that all bills have been paid. Bills coming to the President after January 1, when the Secretary and Treasurer closed their books, so far have amounted to about $1 700, which included the printing of the Journal.

Report of the Editor.

January 14, 1920.

Mr. Henry A. Symonds. *To the New England Water Works Association:* I present the following report for the Journal of the New England Water Works Assciation for the year 1919. I would like to explain at this point that the figures in this report have largely to do with Volume 33 of the Journal; they do not correspond with the receipts and expenditures of the calendar year which have been given you by the Secretary and Treasurer.

The special issue containing the history of the 26th Engineers will be printed as a second section of the December, 1919, issue, and will include title page and yearly index, but is not considered in this report as it is largely essentially an extra.

The accompanying tabulated statements show in detail amount of material in the Journal.

Size of Volume. — The volume contains 727 pages, an increase of 170 pages from that of 1918.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge.

Circulation. — The present circulation of the Journal is:

Member, all grades	899
Subscribers	80
Exchange	23
Total	1 002

a decrease of 8 from the preceding year. Journals have been sent to all advertisers.

Advertisements. — There has been an average of 28 pages of paid advertisements, with an income of $1 863.75. an increase over last year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the

value of $18.90 have been sold. There were 293 copies printed, at cost of $43.95. Price has been advanced from 10c. to 25c. per copy. The net gain up to a year ago had been $322.15, so that the total net gain from this source to date is $297.10, and 273 copies of specifications on hand, $68.25 worth if sold at retail.

Proceedings.

The Association has a credit of $1.52 at the Boston Post Office, being the balance of money deposited for payment of postage upon JOURNAL at pound rates.

The following tables are for Volume XXXIII, not for the calendar year, and receipts and expenditures show total charges and accounts payable with no reference to amounts actually received or disbursed.

TABLE 1.

STATEMENT OF MATERIAL IN VOLUME XXXIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1919.

Date.	Pages of								
	Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	Total Cuts
March	81	60	141	...	33	4	2	180	29
June	68	8	76	...	33	4	0	113	8
September	123	47	170	...	33	4	8	215	41
December	165	14	179	...	33	4	2	218	32
Total	437	129	566	...	132	16	12	726	110

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXXIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1919.

Receipts.		*Expenditures.*	
Advertisement	$1 863.75	Printing JOURNAL and mailing	$2 842.41
Sale of JOURNALS	129.00	Printing and preparing illustrations	950.49
Sale of reprints	39.20	Editor's salary	300.00
Subscriptions	261.00	Editor's incidentals	18.08
	$2 292.95	Advertising agent's salary and commission	116.50
Net cost of JOURNAL	2 675.04	Reporting	312.51
		Reprints	428.00
	$4 967.99		$4 967.99

TABLE 3.

COMPARISON BETWEEN VOLUMES XXIII TO XXXIII, INCLUSIVE (OMITTING VOLUME XXXI), NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. XXIII. 1909.	Vol. XXIV. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.	Vol. XXVII. 1913.	Vol. XXVIII. 1914.	Vol. XXIX. 1915.	Vol. XXX. 1916.	Vol. XXXII. 1918.	Vol. XXXIII. 1919.
Average edition (copies printed)	1 000	1 150	1 000	1 000	1 000	1 050	1 325	1 500	1 388	1 200
Average membership	710	732	752	740	745	803	904	1 002	951	902
Circulation at end of year	802	827	840	826	858	951	1 079	1 155	1 010	1 002
Pages of text	459	643	475	401	554	564	596	538	398	566
Pages of text per 1 000 members	646	880	632	542	746	702	659	538	417	627
Total pages, all kinds	627	808	654	567	733	719	776	707	557	726
Total pages per 1 000 members	884	1 090	870	766	984	895	859	707	584	805
GROSS COST:										
Total	$3 111.15	$3 490 81	$2 625.87	$2 476.55	$3 586.29	$3 345.87	$4 243.35	$3 386.63	$3 115.00	$1 967.99
Per page	4.97	4.32	4.02	4.37	4.89	4.65	5.47	4.79	5.59	6.84
Per member	4.39	4.78	3.50	3.35	4.81	4.17	4.68	3.38	3.26	5.51
Per member per 1 000 pages	7.00	5.90	4.09	5.90	6.46	5.80	6.02	4.79	5.85	7.59
Per member per 1 000 pages text	9.56	7.44	7.36	8.35	8.68	7.39	7.85	6.30	8.19	9.74
NET COST:										
Total	$789.98	$1 334.06	$352.82	$98.81	$1 322.90	$1 155.33	$2 091.09	$1 171.98	$694.50	$2 675.04
Per page	1.26	1.65	.54	.17	1.80	1.61	2.70	1.65	1.25	3.68
Per member	1.11	1.82	.47	.13	1.78	1.14	2.32	1.17	.73	2.97
Per member per 1 000 pages	1.78	2.25	.55	.23	2.42	2.00	2.98	1.65	1.31	4.09
Per member per 1 000 pages text	2.43	2.83	.98	.33	2.38	2.55	3.88	2.17	1.83	5.25

It seems to be " up to " the Editor at this time to present the rather serious financial status of the Association.

During the years of the war, we have lost a large number of members, but the inevitable additional cost of running the Association, and especially publishing the JOURNAL, is giving the officers and the Executive Committee a difficult problem to solve, in order to make expenditures come within the receipts.

The publishing of the JOURNAL is the large item to be considered, and there are two general methods of helping out the financial situation in our policy with reference to the JOURNAL.

The first is to curtail the publications, cut down all discussions to a minimum, and perhaps publish only a fraction of the papers presented. When it is considered, however, that an average of nearly nine tenths of the members of the Association who pay the dues are not able to be present at the meetings, but get their benefit through the JOURNAL, it does not seem that this is the proper solution, or that we can expect to maintain or extend our membership if this policy is carried out. It will be possible to make some minor economies which will not make the JOURNAL less valuable to the members, but the total amount to be saved in this way is not large.

The second method of solving this problem is to find means of increasing the revenue. It is probably possible to make some gain by advance in advertising rates, as we are informed by the best authorities that advertising rates, like everything else, are being increased, and that we are entitled to make an increase for this purpose. Additional price for subscription will give a slight help. It may, however, be necessary for the Association to consider an increase in dues in the near future, if it is to be the policy to publish the JOURNAL on the same lines as formerly.

Respectfully submitted,

HENRY A. SYMONDS, *Editor.*

THE PRESIDENT. You have all heard the reports of the Secretary, the Treasurer, and the Editor. What is your pleasure in regard to them?

(On motion of Mr. Charles W. Sherman, duly seconded, the reports of the Secretary, the Treasurer, and the Editor were accepted and placed on file.)

ADDRESS OF THE RETIRING PRESIDENT.

PRESIDENT KILLAM. The Association has added another page to its history of achievements through the work of its officers, committees, and members, in the advancement and exchange of knowledge relating to the construction and management of water supplies.

Many of you who have been attending these meetings for many years will recall the days when the membership was made up chiefly of superintendents of water works, men who had been raised from the ranks. They came to these meetings in order to learn how to solve particular problems

in which others had had experience, and in return they were willing to relate their successes or failures. Time has changed these conditions. The old-line rank-and-file water-works man is seldom seen at the meetings to-day, and if perchance he does attend he quietly slips into one of the rear seats and never a word comes from him. Is it because our papers have been too technical? I believe that, while the older members deprecate the fact that we do not have as many papers read to-day by superintendents of water works, yet they feel that the times have changed from the problem—which in the past was one of distribution, as there was plenty of good water in the earlier days—to one of quality as well as quantity. I believe that the superintendents feel much indebted to the highly trained men who have specialized in this line of work for the technical help that they have received through papers and committee work.

The Association has always been noted for the excellent work of its special committees, and the growth in influence and ability to benefit its members has been largely due to the reports and conclusions of these committees. In order to continue this successful work, the cordial co-operation and assistance of the general membership of the Association is necessary.

Our Association will grow according to the worth it is to the individual. Our Journal, which has long maintained its reputation as the leading publication on water-supply matters, should be made more valuable to the average water-works man. The trade papers, who employ especially trained men, condense the articles presented in open meetings and the important information is available to our members long before the papers are printed in our Journal. This is logical, and no criticism of the trade press is intended, as it is the chief aim of our Association to diffuse data of value to the water-works fraternity which cannot be any better and more quickly accomplished than through the trade publications. The Journal should be strictly a water-works magazine. The papers should be well edited and blue penciled, and there should be an increase in the advertising. The committee on publication has an opening through the Journal to collect and publish water-works papers and data which have not been presented in open meetings, and such information could therefore be obtained only through our publication.

Comparatively few people in any community appreciate the water-works officials and the many difficulties attending the successful management of their works. If we can convince these officials who are not members, that this Association does appreciate their services and is willing to share their burdens, I believe that there will be a decided increase in membership. We need new members, and you have adopted the recommendation of your Budget Committee to make a drive. An intensive drive will cost money. If we are to continue to grow and maintain our standing among the technical societies of our country we must make individual efforts.

Let us start the new year with the slogan, " Let every member get a member." Drives are all right. They get quick results, but I believe that the individual effort of each member is most desirable in order to increase our membership and still be healthy. The responsibility rests upon us. Will we not accept it and render the service?

The annual convention was held at Albany, N. Y., and was attended by 396 members and guests. The exhibits were interesting and instructive, and very artistically arranged. The literary program was excellent, and the meetings were well attended. The entertainments were very enjoyable and called forth many favorable comments. This last feature was handled by a committee from the Water Works Manufacturers Association, which has been seeking this privilege for ten years. The idea of allowing a man to spend his own money proved advantageous to the Association. I trust that future conventions may gain in size and influence.

I thoroughly appreciate the support and consideration of the officers during the past year, and thank the members for the courtesy and kindness they have all manifested toward me during my year as President, and I congratulate the Association on the loyalty of its members.

Let us ever bear in mind that we live in deeds, not in years, and that the New England Water Works Association can move onward and upward only by the hearty coöperation of every member. [*Applause.*]

Election of Officers.

The President. The next thing in order to-day is the report of the tellers.

Mr. Thomas E. Lally submitted report of tellers, and the following were declared duly elected for 1920:

President, Henry V. Macksey.

Vice-Presidents: Charles W. Sherman, Frank A. Barbour, Percy R. Sanders, Beekman C. Little, James H. Mendell, William W. Brush.

Secretary, Frank J. Gifford.

Treasurer, Lewis M. Bancroft.

Editor, Henry A. Symonds.

Advertising Agent, Henry A. Symonds.

Additional Members Executive Committee: A. R. Hathaway, Patrick Gear, David A. Heffernan.

Finance Committee: George H. Finneran, George A. Carpenter, Frank A. Marston.

The President thereupon declared the above-named gentlemen to have been elected officers of the Association for the ensuing year. Addressing Mr. Macksey, the retiring President said:

" It now gives me great pleasure to resign to you the chair and the gavel of the Association of the New England Water Works. I congratulate the Association in having elected you as President, and I trust that you will have as enjoyable a year as I have had during 1919." [*Applause.*]

Address by President Macksey.

Members of the Association: Although I knew that I should be called upon to speak, I have prepared no address for this occasion. You have had many long reports to listen to, and have some entertaining speakers for the day, and the hour grows late. You will have to listen to me many times during the coming year.

I congratulate myself not only on the great honor you have conferred upon me in electing me as your President, but also on my good fortune in having so many able men with me on the board of government. I speak not only for myself but for them when I say that we will endeavor to make the coming year as successful as Mr. Killam and his board have made the past year, a year when, under most discouraging circumstances, the President, with the assistance of his board, did very creditable work. On this board we have a new Secretary. That is a most important place, and we have a good man to fill it, and I hope he will give us as good and faithful service as has the retiring Secretary, who served many years faithfully, who did good work and had the respect and the confidence and the love of all those members who knew him. [*Applause.*]

The many problems that have been brought up incidentally, as these reports have been read to you, may be boiled down to the old, old questions of membership and money. The Association to be strong must have new blood and young blood put into it, and a steady stream should be coming in, else we old fellows, who are becoming slowly fossilized, will allow the Association to grow cold. We must have sufficient money in order to return to the members good service, service of which they may be proud and which may keep up the reputation which this Association has had, and has to-day, the world over.

As your Editor has just told you, you have a very serious problem before you in regard to your Journal. I do not believe that it will be necessary for us to cut the quality of the Journal, and probably not the quantity. We will have a good Journal or none, and we will pay for it. It is not an unusual thing to-day to be told that you must pay more money for what you have been getting, and it is rather difficult for us who are salaried men, superintendents, engineers, and others, to be called upon to pay ever-increasing prices for all the necessaries, as well as the luxuries, of life, while our incomes remain practically stationary.

For the man who is in business, who is represented here by our associate members, the conditions are a little more favorable, for, while he may not accumulate much more wealth, he certainly handles much more money. We do not intend to say to the associate member that we propose to place the load upon his back, we merely ask him to help us, and there is one way that he can help us and help us greatly without any expenditure of money, and that is in the procuring of new members. As you all know, each superintendent sticks pretty closely to his own town. He may see the

men in his trade or profession within a radius of a few miles, but that is all that he meets except those who are members and whom he meets when he attends these meetings. But I have noticed a few of the associate members who travel through the country selling goods to the cities and towns in which water-works men are located, have found new members for us, and it seems that they all should enlist and do that missionary work, because they go into a town the moment a new superintendent comes in, the moment a new city government comes in. It is their painful duty to get on the job at once and get acquainted.

My experience with the associate members is this, — I am always glad to see them come, and regret when they go. They are all good fellows, and the superintendents like them and take their advice and the knowledge which they pass along. Their judgment is good, their advice is good, and they are fair and honest, and do not try to fool us. If our associates will make it a point to try to help us extend the membership of this organization in cities and towns where we now have no members they will be doing more for us than they could do with money, because we need men even more than we need money. That is the one thing that to-day I ask the associate members to remember.

I would not have it thought that the load should be taken off the active members' shoulders. Will each one think it over? Don't you know some one man who is a good man — because it is good men we want — that you could induce to become a member of this Association? If so, will you go to the trouble and expense of bringing him down here once, show him what we have got, and induce him to join? That is the kind of work we want done. If you will all enlist actively in the campaign I think you can rely upon the board of officers to so manage your affairs that you will not be ashamed of the record of the Association for the coming year. We have a good record so far and a hard one to beat, and we will try to beat it. [*Applause.*]

Election of Honorary Member.

Mr. Samuel E. Killam. Mr. President, twenty years in a man's life is a long, long time. In talking to a man, recently, he spoke about his position and said, "I ought to get out of here and do something better; they are offering all kinds of inducements outside." I said, "Well, why don't you?" "Why," he said, "I have been here twenty years, now, and I don't like to make a change."

I think that is so with the water-works officials and engineers; they are in the positions that they have grown up in, and twenty years to them seems a long time, the best part of their lives.

But when you consider twenty years being secretary of an organization of this kind, — and those of you who have served as officers know what it means to prepare meetings, to get data to present at your meetings, and papers to publish in your Journal that will keep the standard as high

as it has been — any man that goes through this for twenty years and makes very few enemies is, to my mind, a wonder. And such you have had with you during the last twenty years.

Mr. Kent, your retiring Secretary, has been one who has been loved by all the members, and he has been a hard worker and a faithful worker, a credit to the Association and an honor to himself.

Your retiring Executive Committee recommends, and I so move, that Mr. Kent be made an honorary member of the Association, for the good and faithful work that he has done in the past.

(The motion is seconded by several members with applause.)

Mr. Charles W. Sherman. Mr. President, while the motion has been informally seconded by many of the members, I want the honor of formally doing it. When I first became a member of the Executive Committee of this Association, Mr. Kent was made Secretary. He was then, as you know, a past president of the Association. I served with him for eight years as editor, and then found that I had to retire. Mr. Kent has stuck it out twice as long. I certainly want to appear as the formal seconder of that motion.

The President. Gentlemen, you have heard the motion that Mr. Willard Kent be made an honorary member of this Association. Were it not for the fact that the President should not make a speech, I could spend considerable time adding to what Mr. Killam and Mr. Sherman have said in regard to the value and our appreciation of the services of Mr. Kent.

(The motion was unanimously carried by a rising vote.)

The President. It gives me great pleasure, Mr. Kent, to declare you elected an honorary member of the Association. [*Great applause.*]

Mr. Willard Kent. *Mr. President and Gentlemen:* I was too old to go to war, but this is as unexpected to me as the call on my friend on the left was to him a moment ago.

I thank you for your kind words and expression of good-will. One of the great advantages of being secretary is the opportunity afforded for meeting good fellows. As my duties are closed, the agreeable episodes stand out strongly in my memory; whatever there may have been of perplexities and annoyances is forgotten.

I think it is generally understood that the secretary's duties are to record the sayings of others rather than to talk himself, at least that has been my conception of them, and I will not deviate now.

I believe that in the thirty-seven years of your existence as an Association you have accomplished a very considerable measure of success in advancing the knowledge and promoting the interests of public water supplies. It is my earnest wish that in the future you may have a still greater measure of success, to be accomplished by the hearty coöperation and active participation of all the members, and that cordial relations of good-fellowship among you may ever continue. [*Applause.*]

Adjourned.

February Meeting.

Hotel Brunswick, Boston,
February 11, 1920.

The President, Mr. Henry V. Macksey, in the chair.

Announcement was made by Secretary Gifford of the deaths during the past month of R. Winthrop Pratt and Frank L. Fuller. The President later announced the appointment of Messrs. X. H. Goodnough, E. G. Bradbury, and George W. Fuller as a committee to prepare resolutions on the death of Mr. R. Winthrop Pratt; and Messrs. F. C. Hersey, Jr., John C. Chase, and George E. Winslow as a committee to prepare resolutions on the death of Mr. Frank L. Fuller.

The following, duly approved by the Executive Committee, were elected members: Patrick E. Kelly, Cambridge, Mass., civil engineer; W. G. Classon, Leominster, Mass., civil engineer; Robert E. Ferguson, Medford, Mass., water commissioner.

Secretary Gifford. Mr. President, your Executive Committee has recommended that Walter H. Richards, of New London, Conn., be made an honorary member.

The President. Gentlemen, you have heard the recommendation of the committee, and in relation to that matter I want to read you a short letter which I got from one of the old members:

Derry Village, N. H.,
February 7, 1920.

Mr. H. V. Macksey,
Woburn, Mass.

Dear Mr. Macksey, — Mr. Walter H. Richards, of New London, Conn., is the third in seniority of the present members of the New England Water Works Association. He has been the engineer and superintendent of the water works and sewerage system of that city since 1872. For several years he was the junior editor, and rendered valuable service to the Association in that way. He is now in failing health, and I think that his being made an honorary member and relieved from dues for the rest of his life would be a very graceful act. He was not a charter member but came in at the first meeting of the Association. This is written without his knowledge or suggestion and I trust will be received in the spirit in which it is written. All of the charter members have been put on the honorary list and many others who came in later than Mr. Richards. Hoping that you will bring this matter up at the next meeting, I am

Very truly yours,

John C. Chase.

I quite agree with Mr. Chase, and will be very much pleased to receive a motion to elect Mr. Richards as an honorary member.

Mr. Thomas McKenzie. Mr. President, I move that the recommendation of the Executive Committee be adopted and that Mr. Richards be elected an honorary member of this Association.

(The motion was duly seconded and unanimously carried.)

President Macksey brought up the matter of the lunch and submitted

sample menus of the \$1.50 (now served) and the \$2.00 luncheons. He stated that \$1.50 was the minimum price charged at the Brunswick for luncheon and that prices at City Club were about the same.

At the American House a more liberal amount served for the same money — quality about the same, service and conveniences much below that at Brunswick.

Informal vote taken on preference of present priced or the \$2.00 luncheon.

Fifteen voted in favor of continuing the \$1.50 luncheon; eight voted in favor of the \$2.00 luncheon.

Mr. Charles W. Sherman. Mr. President, I have here a resolution which I have been asked to present:

"Whereas: The public works functions of the Federal Government are now scattered through nine separate departments and thirty-nine bureaus and services; and

"Whereas: This independent operation and competitive relation of like functions in a large degree renders the Government uneconomical and inefficient in its business conduct;

"Be It Resolved, that the New England Water Works Association endorses the proposition to organize under one department the many and varied public works and engineering functions of the Government as provided for in the Jones-Reavis Bill (S. 2232, H.R. 6649);

"Be It also Resolved, that copies of these resolutions be sent to each New England Senator and Representative."

I move the adoption of the resolution.

(The motion was duly seconded and carried.)

The President. At the last meeting the associate members were asked to use their endeavors towards advertising the good points of this Association and bringing in new members, either active or associate. *I am pleased to say that some of the associate members have started to work and have shown results, and we are very grateful, and hope that the good work will go on.* If any associate member needs application blanks, if he will just leave his card with either Miss Ham when he is up at headquarters, or with Mr. Gifford or myself, we will see that they are promptly forwarded to him.

Mr. Edward D. Eldredge, superintendent Water Company, Onset, Mass., presented a paper entitled, "Economy in Pipe Lines for Small Water Systems." The discussion was participated in by Messrs. D. A. Heffernan, H. J. Goodale, Geo. A. King, John C. Chase, Henry A. Symonds, Joseph A. Hoy, Samuel E. Killam, Patrick Gear, President Macksey, and Leonard Metcalf.

In the absence of Prof. George F. Swain, of Harvard University, who was to have presented a paper on "The Creation of a National Department of Public Works," Mr. Robert S. Weston read a paper on this subject.

Adjourned.

IRVING SPARROW WOOD.

Born in Providence, November 26, 1857, and was the son of the late Charles P. and Sarah S. Wood (*née* Robinson). Mr. Wood died October 20, 1919, in the old homestead where he was born and lived since childhood.

Mr. Wood in his earlier years attended the common schools of Providence, and later went to Mowry and Goff's English and Classical School, from which he was graduated in 1877.

After his graduation he entered the city engineer's office in Providence, as a student in civil engineering. The first work to which he was assigned was assistant on bridges and on the Brook Street improvement scheme under Mr. Henry B. Francis.

Mr. Wood was employed in the various engineering departments, being assigned to the Water Department under the late Edmund B. Weston. At the time of Mr. Weston's resignation from the city engineer's office, May 1, 1894, Mr. Wood succeeded to the position of assistant city engineer, in charge of the Water Department, where he remained until his death.

Mr. Wood was elected a member of the New England Water Works Association on March 8, 1905; of the American Society of Civil Engineers, March 6, 1906; of the Boston Society of Civil Engineers on December 20, 1899, and of the Providence Engineering Society, April 30, 1918.

His general health began to fail the last year of his life, but he attended to his duties faithfully until October, 1919, when heart trouble developed and the end came.

In October, 1903, Mr. Wood was married to Miss Margaret E. Reed, who with an only sister survive him.

Although not a member of the Union Congregational Church in Providence, he made that his home church, where he was loved and respected for his upright character and cheerful disposition.

George H. Leland.
Samuel M. Gray.
Frank E. Winsor.

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ECONOMY IN PIPE LINES FOR SMALL WATER SYSTEMS.

E. D. ELDREDGE.*

[*February 11, 1920.*]

The present cost of water-works construction is so great that any details that show a possible saving are worth considering. Let us consider a simple case, that of a small and variable population in a relatively large area of irregular layout of streets. The average summer resort or old-time village comes under this description. Parts of larger towns and cities may sometimes be included. This applies, perhaps, to New England, more than to any other part of the country. The benefit of pleasure and healthful recreation leads many to the country or seashore. Some of the interesting features of such resorts are often the irregular and rambling streets and lanes. The need of better water supply soon arises. It is hardly worth while to install a water system without including a good fire protection available the year round. This calls for a pipe system, in some cases, larger than is needed for the domestic supply alone, nothing less than 6-in. being permissible for hydrant connections. It is the best policy, of course, in cities where the consumption is large throughout the year, and where sufficient funds are available, to use pipes amply large. Cast iron is the favorite pipe. But now in the small town we find many conditions under which a system can be designed with two points in view, one the fire service and the other the domestic. First the location of the hydrants should be chosen, and this with due regard for probable extensions. Then the pipes of sufficient size to supply them should have their best location chosen. Now we come to the domestic requirements, a large part of which is supplied directly from the fire lines. Many houses, however, are in short cross streets or on lanes, a considerable distance from the large mains. In the case of shore resorts the limits of settlement are in some directions confined by the water boundary, where no further extensions will occur. Why should domestic services, if they are at a distance from the fire lines, be supplied from pipes larger than necessary, particularly if they are occupied only during the summer?

* Superintendent of Water Works, Onset, Mass.

Large lines of cast iron give red-water trouble when the consumption is small and the temperature of the water is low.

The solution is found in the judicious use of small pipe lines connected at favorable points to the fire mains. This composite system will be found amply suffiicient to a surprisingly large extent, if proper pipe is used. Moreover, a small line of wrought-iron threaded pipe, 2-in., 1½ in., or 1¼ in., cement lined, will not only do the work but will do it decidedly better than a larger cast-iron main, as it is not subject to internal corrosion or tuberculation, and does not produce red water. The experience of over twenty years is the basis of this statement. Pieces cut from a line show the pipe to be in perfect condition. It should be stated that this type of cement-lined pipe is that quite commonly used for individual service pipes, and is entirely different in its characteristics and durability from the old type of 6-in. thin sheet-iron cement pipe, which is being replaced as opportunity offers.

The 2-in. cement-lined pipe is connected to the cast-iron fire mains in various ways, the favorite method being by using a tapped tee in the main or a tapped plug in a cast-iron tee or cross. If the branch is to be connected to a main not provided with such a tee, two or more ordinary corporations may be put in, connected by means of a manifold, having all the iron parts cement lined. Iron-body gate valves are used, also cement lined, except, of course, the brass working parts.

The principal point of excellence in the execution of this work is due to maintaining a continuous and complete cement interior, allowing no chance for metallic iron exposure to the water. This is possible, but in too many cases its use is avoided on account of the supposed difficulties and the care necessary. It is a class of work in which a change of workmen should be avoided. Men become accustomed perfectly to its use.

In most cases a water works requires a few permanent men. At times in the winter there is but little outside work. This furnishes the opportunity for these men to turn to the work of cementing a lot of pipe for next season's use, as is now the custom of a few concerns in the preparation of 1-in. service pipe. The same men prepare the pipe and lay it; thus a certain perfection is attained. In all cases of service pipes direct from the fire mains, the cement lined is used. With the standard work a ¾-in. pipe, lined, is sufficient for the ordinary house service, the pressure being about 45 lb. In good soil, particularly where it is sandy, a rigid connection is satisfactory. Not one such connection has failed out of nearly 900. The corporations are tapped level in the side of the main.

Cement-lined pipe of this type stands all the bending ordinarily needed without the least injury to the lining. For prospective service connections to a cement street main, tees with ¾- or 1-in. plugged branches were introduced at desired intervals, as the pipe was laid. The tees were cemented integral with a nipple about 4 in. long. This nipple, with the

tee combined, was screwed into the coupling on the main, thus avoiding the removal of a coupling and an imperfect joint resulting.

The full lengths of two-in. or smaller pipe are more convenient to line, inspect to insure perfection and to handle, if cut in two. The short lengths give better chances for location of tees, which are placed with some freedom and a record made. Some pieces 4 or 5 ft. long are kept at hand, all with couplings well screwed on before lining. If it becomes necessary to cut a pipe, as for accuracy in locating a gate, a hack saw is always used, to preserve the plane of the cut.

No outside men are allowed to lay any service pipes. All underground pipes attached to the system are laid by the water-works men.

In some localities the ground will permit tunneling, which saves about one half in the excavation, and is perfectly adapted to the requirements of laying threaded pipe in half lengths.

Discussion.

Mr. D. A. Heffernan.* I should like to ask Mr. Eldredge in regard to the metal of the 2-in. valve, and lining of the composition part.

Mr. Eldredge. There is a recess between the brass seat and the end of the thread. On a 2-in. gate there is a space nearly three fourths of an inch, which is cored out larger than the opening of the valve. That space will permit of lining, and will hold the cement all right. When the joint is screwed together the cement on the pipe comes in contact with the cement in the valve.

Mr. Heffernan. How are the joints protected where the pipe is screwed together? Is it a fact that you can bring the cement surfaces, of two separate pipes, together, at a joint; or is something placed there after the pipes are screwed together to keep the water away from the iron?

Mr. Eldredge. It is possible to bring the two continuous linings of cement together. In some cases a brass ferrule has been slipped into the adjoining ends to bridge any space. It is, however, possible to line the pipe with coupling on, and after the cement has partly set, to trim out the coupling, till the lining is at a proper distance within the coupling, so that when the next pipe is screwed in it will butt against the cement already in the coupling. This process works as well in 2-in. pipe as in the smaller sizes. One point that has proved perfectly possible in the service connections is the use of $\frac{3}{4}$-in. pipe. It is not customary to use pipe as small as that, but it has done all right for twenty years and the ordinary house gets plenty of water through it. It is more convenient to operate, and cheaper and better in many ways, than the inch pipe.

Mr. H. J. Goodale.† What would be the diameter of $\frac{3}{4}$-in. pipe or 2-in. pipe after it had been lined?

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* Superintendent of Water Works, Milton, Mass.

† Superintendent Public Works, Attleboro, Mass.

Mr. Eldredge. Three-quarter-inch pipe makes up to about 9/16, and while that size seems a little small the interior of the pipe is smooth, and the friction loss through it is very slight. More water will go through that than through a half-inch galvanized pipe. With a 2-in. pipe the lining is about a quarter of an inch thick.

Mr. George A. King.* I should like to ask Mr. Eldredge what kind of cement is the best lining.

Mr. Eldredge. The best cement is the old-fashioned Rosendale cement, — Hoffman, and various brands. In fact, the Portland cement is not satisfactory; the other cement sets more slowly. The process of lining, which most of us are more or less familiar with, is to fill the pipe two thirds full of cement and then draw a plug through it on a wire. The operation possibly has to be repeated, by drawing the plug through a second time, to get a perfect surface. But it is a perfectly practical thing, easily done.

Mr. King. You do not grout it?

Mr. Eldredge. No, it does not seem to need it.

Mr. King. Mr. Forbes, of Brookline, does.

Mr. Eldredge. Yes, I know; but it does not seem to need it.

Mr. Henry A. Symonds.† Has there been difficulty in getting the cement centered? It may not make a great difference in the efficiency of the pipe, but it seems better to have uniform thickness of cement all around. One superintendent of water works has been able to get concentric lining, by using two sets of fins on the leading plug.

Mr. Eldredge. There is much less trouble than would be supposed. As I said, we always cut the lengths in two, which gives an opportunity for inspection, to see clear through the pipe. The plug that is used has one set of wings. If the pipe appears all right on inspection, if the cement is continuous, no breaks in it, it is all right. It doesn't make any difference if it is not perfectly concentric. That has been demonstrated upon pieces that have been cut after some years of service and found to be quite eccentric, and still no defect arises.

Mr. King. We had some trouble on account of lining not being centered, the trouble caused by the back end of the plug dropping down, but by increasing the length of the fins we obviated that.

Mr. Heffernan. I think that the use of the hacksaw mentioned by Mr. Eldredge is very important. Some mechanics use the regular pipe cutter, with the result that the cement at the end, where the cut is made, crumbles, and later on the water will have some effect on the iron pipe.

For lining the pipe, we use the Rosendale cement. That is a slow-setting cement. The Portland cement is quicker setting, but I do not think you get as good results. We began by lining in 19- or 20-ft. lengths,

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* Superintendent of Water Works, Taunton, Mass.

† Civil Engineer, Boston Mass.

the ordinary length. The inspection could not be made properly, so that we now cut the pipe in two to give us a chance to inspect closely. The regular cone or plug which was used to go through the pipe came in the original two sections, and we found that it was more or less difficult to get a smooth lining; in fact, we did not get it. And so we had the manufacturers make a cone 2 ft. long, which we now use, and it gives good satisfaction. If anybody does have any trouble, if he will try a cone about 2 ft. long and use the Rosendale cement, I think he will get a perfectly lined pipe.

Mr. Joseph A. Hoy.* Our pipe will average anywhere from 20 to 21 ft. in length, and our process in Worcester is to ream the ends out and then put the rods through, practically the size of the inside diameter of the pipe. We place them in the cellar, and mix the Rosendale cement. The same man usually does the mixing. Our cone has fins on it and a follower attached. It may be necessary to fill two or three times after the cone has been pulled through. A lamp is then placed at each end. The operator looks, and if he sees that there is a place that has not picked the cement up, he puts in a little more and pulls the cone and the follower through again.

Can you tell me approximately how many feet you will line in an eight-hour day?

Mr. Eldredge. Well, it would vary somewhat, but we expect to line 500 or 600 ft.

Mr. Hoy. We line in an eight-hour day — three men working — from 900 to 1100 ft. That is either 1-in. lined to ¾ in., or 1¼ in. lined to 1-in. We also line the couplings, but, as Mr. Heffernan said, you may start the cement in the couplings. If you line the inside of the pipe up to the thread you are going to grind some of the cement off. I think the surest way is to put a little cement in the coupling, screw it on the pipe, have your cone in place, and pull it through. Then it all depends upon the weather, whether you ought to put a little powder around and start a fire to harden it up, or whether the water is going to be turned on right away and flush it out again.

Mr. Heffernan. It may be well to know that the lead-lined coupling is a very useful coupling to use. We use lead-lined couplings, and they give a perfect joint, as there is no danger of cement crumbling where two joints come together, and we are sure of getting the joint tight. Does any trouble occur from the cement coming out of the coupling? We have had that difficulty, but the lead-lined couplings entirely eliminate the possibility of the cement being broken out of the couplings when the pipe is made up.

Mr. Samuel E. Killam.† I have not been very successful in bending cement-lined pipe. That is, my foreman thought he had been, but I

* Foreman Water Department, Worcester, Mass.

† Superintendent Pipe Lines and Reservoirs, Metropolitan Water Works.

insisted that it be taken out and cut, and found that the cement was cracked away from the pipe. How much can you bend a 10-ft. length with safety?

MR. ELDREDGE. You can bend a 10-ft. length 10 or 15 degrees. You can perhaps do better than this if you make the bend with a sufficiently long radius and do not confine it to one spot. It is difficult to explain, but for some reason a very considerable bend can be put in without injuring the cement.

MR. PATRICK GEAR.* Do you have any trouble where the cement might break, and then go through and get into the meter?

MR. ELDREDGE. I never knew of any breakings where the two ends screwed together. They might grind some of it off, but it doesn't come off in the form of chips but in the form of powder, and the first operation of cleaning the pipe, blowing through, removes that, and there is never any more.

MR. HOY. After your pipe is lined, Mr. Eldredge, — after it is practically baked in from standing there, — do you run a thin grouting through and pull a rubber follower through it to cover up any little spot that you might have missed in the process of lining?

MR. ELDREDGE. No, we do not, for the reason that the third man, or inspector, discovers any defects. We do not allow any to pass that has any defect in the cement, but put a little more cement in and run the plug through again.

From some of the questions that have been asked it seems that it is not always the custom to use an extension on the pipe in the process of lining. On both ends of the pipe it is best to screw a nipple about 15 to 18 in. long, and let the plug enter and leave from those nipples. That is where unavoidable roughness will occur. The pipe that is between the two nipples will have a perfect surface.

MR. HOY. On the finishing process there we mix a thin grout. We pour the grout in and have the pipe on an incline, then bring the pipe up practically to a level and pull a rubber cone through, which practically takes off any little blisters there may be or cover any spots which were left.

MR. ELDREDGE. I think that is quite a common method and doubtless is an excellent system, but it is just one of those points that whatever method you get started on you can develop in one direction, while some other person develops in another direction.

MR. HEFFERNAN. Do you, Mr. Eldredge, ever figure the cost of lining $1\frac{1}{4}$-in. pipe to 1-in.; also, is the pipe given a coating — where the wrought-iron pipe is galvanized?

MR. ELDREDGE. We use principally the black wrought-iron pipe, although some galvanized. If the pipe is to be put in any place where the ground is wet or in the neighborhood of salt water, we would use galvanized. In one case where a 2-in. pipe was laid near a salt beach, a rough

* Superintendent Water Works, Holyoke, Mass.

coating of cement was applied on the outside after it was in the trench, to protect it from the salt water. That pipe was opened ten years afterwards and found to be in perfect condition. When the pipe is trimmed out, finished, and all defects at the ends corrected, the last operation is to give it a coat of asphaltum paint and put a little oil on the threads. The threads are always inspected.

As to the cost, it is rather a variable quantity. It is not always possible to figure the actual cost, for the reason that it is a job that can be done while wages are still going on, and it does not add anything to the cost of the pipe. It is usually not a very expensive part of the business.

Mr. Heffernan. We line our pipe during the winter, when those men are doing nothing else. A certain charge per foot to the consumer must be made. Have you adopted a plan, Mr. Eldredge, of charging so much a foot for the pipe and so much for the digging?

Mr. Eldredge. Yes.

Mr. Heffernan. What do you charge for the inch pipe per foot?

Mr. Eldredge. We charged 15c a foot for the $\frac{3}{4}$-in. pipe up to last season. The price is a little higher now; last season for inch pipe we charged 18c. That did not include the cost of laying, which varies with conditions. Two or three cents a foot would cover the expense of the cement lining of the smaller sizes.

President Macksey. It is interesting to note that the discussion of this paper has been on the detail and not on the general principle, and I think the general principle is one to which we should give some study. The question is, whether we can go on as many of us are doing, putting in large cast-iron pipe, 6 in. in diameter, where there is a call for water which might be supplied through a pipe of 1 or 2 in. diameter. It is true we are building for the future, but can we afford to go on doing so? There are so many things to pay for in water-works service at this time. The cost of everything connected with the water-works construction and service has increased about 100 per cent., whereas the selling price of water has gone up not more than 25 per cent.

Is Mr. Eldredge right in saying that we should in very many cases neglect, for the time being, the growth of the district we are about to supply and provide no fire protection? If water service is paid for by the municipality, the municipality as a whole demands water service for practically everybody, and unless you have a board of survey in your city or in your town some real estate speculator may buy up a farm, or a lot of waste land, and cut it up into building lots which look beautiful as shown on the blueprint. He has utilized every square foot of his land, and has given you all the street fronts that it is possible to give with the limited amount of land which he has. In many cases you find that the development is such that it is a criminal waste of money to lay water mains through the alleged streets which have no proper lines and grades. If you give water service to-day, you may find that in the future either

your pipe will be near the surface, perhaps above ground and liable to be frozen, or buried so deeply that it is difficult to find when there is a break, or when a service connection is to be made.

It is a matter which every superintendent and every man responsible for the financial condition of water companies should carefully consider: shall we supply just what is actually needed to-day or shall we supply fire protection also; shall we build for to-day only or for the future? That is the main thought in Mr. Eldredge's paper, which should be discussed. We should all bear it in mind when we are developing any works with which we are connected.

Mr. Symonds. I feel that Mr. Eldredge has presented a subject that we hardly realize the importance of at this time. We are at a point where we have got to change a good many of our views as to the apportioning of mains for supplying water. Within the last six months a Massachusetts town has had a complete design made for a water-works system, and entirely eliminated the question of fire protection. It is unfortunate that such action is necessary, but when it came to actually figuring the expense of a fire protective system it became evident that it would be excessive.

In the past it has usually been, in communities of substantial size, a very easy matter to show that a large saving in the insurance rate would result from the installation of a suitable system. In a case which has come to my attention in the last week I attempted to figure out and prove by the old method, allowing what seemed to be a fair amount of insurance to be carried in that particular community, taking the rates furnished by the New England Insurance Exchange for the class, for unprotected service, and then the saving which would be occasioned if a protective service were provided by such a plant as would naturally be installed. I was rather disappointed and somewhat surprised to find that no showing at all could be made for a fire protective system as a financial proposition. It was going to cost twice as much for a hydrant rental, which would be a fair rate as would be saved. Of course, there are other features to be considered than the mere saving in insurance rates. But that ratio has been dwindling until we must look at it from a very different point of view.

I hope the time has not arrived when we must design plants for fairly good-sized communities and leave out the fire protection; but I must admit that as a business proposition we have got to cut out the fire protection in many places where it has been entirely practicable and a good business proposition to install it previously.

Mr. Leonard Metcalf.* Mr. President, I had not thought of speaking on this subject, but it occurs to me to suggest that we should differentiate between the different classes of problems that come before us. I am in sympathy with the idea that in many of our extensions in the

* Of Metcalf & Eddy, Boston, Mass.

smaller communities, and in the real estate additions such as our President has referred to, we may well adopt temporary expedients in the light of present prices. On the other hand, when we come to consider the question of adequate service for our larger communities and cities, it does not seem to me that there can be any doubt that it is the wiser policy to continue to build for the future rather than to take the danger and risk which go with the more modest scale of construction.

I met that very problem at Dayton during the war. The works were carrying a burden which was really beyond their normal capacity, — that is, the margins of safety had been used up. They were drafting from a driven-well supply, where they had a fluctuation in ratio of demand of about 5 to 1. Their consumption was perhaps about 15 000 000 gal., from 12 000 000 to 15 000 000, and their maximum draft for short periods of time was up to a rate of 35 000 000 gal. per twenty-four hours. That was a very serious tax on the wells. One of the methods suggested for obtaining relief was to build reservoirs on the hilltops surrounding the city, but the city, of course, was put to it for money, — it was in a very difficult position. It would have built under normal conditions three or four of these reservoirs, probably of 20 000 000 gal. capacity each, but after studying the question I advised that they build one reservoir of 10 000 000 gal. capacity, with proper connection to the distribution system. That ironed out this heavy peak demand upon the wells, and it gave enough water in storage, not only to take care of the fluctuations in demand, but also to take care of serious fire. The city fathers, when they came to discuss the matter, said, "Can't we cut this reservoir to, say, 3 000 000 gal.?" I said, "Yes, of course, you can; but in my judgment you should not; consider the other side of the ledger; you are doing millions of dollars of work in this city for the Government in munition's manufacture, and any interruption of the service resulting from conflagration would be a very serious matter; it does not seem to me that it is wise, for the sake of saving $100 000 or $200 000 on the entire enterprise, for you to take that risk; do it if you please, but do it with your eyes open, recognizing the risk which you are taking." Of course, they appropriated the money and built the larger reservoir, and they are going ahead to-day with important extensions, believing that the risk to the city without margins of safety is too serious.

It is not simply a question of saving in insurance; there is also involved the question of the interruption of the industrial life of the city, and that may be, of course, a very serious matter. I can't help believing that a good deal of our trouble is from not yet having bridged the gap between the old and the new conditions, the effect of disbursement of very large sums of money for war purposes and the great difficulties of our cities in making good the loss of income which they used to get from the liquor licenses. But in spite of that it does seem to me that the really essential work — that is, work which is essential to the maintenance of a high

standard of service — in the industrial district, the commercial district of the city, and the more important residential districts of the city — ought to be met. In other words, that we ought to continue to furnish good service.

Now, even though we have lower prices again — of course, they will never again return to the old figures — we must not overlook the side of the risk which we are carrying in not building adequately during this trying period to meet the future. And when we stop to reflect upon the life of the community, it seems to me that we must admit that the water supply is of fundamental importance. There is no other service of a public nature which is so supremely important to the life of the community as the water supply. Moreover, there is no other service which is so cheap, even at present-day prices, as the water supply. So that I incline to the view that in many of these cases we should screw our courage up to meeting the situation as it is and not go on carrying the burden or risk involved by several years of arrested development. Of course, in the case of the private works that are face to face with the inability to get any increase in rates, — if such there be, and there are some such, — I know the problem is a somewhat difficult one. But even there I think the effort should be made to see whether some means cannot be found for bridging the difficulties so that the service may be bettered in spite of abnormally high prices.

There is another aspect of the matter which I think is of importance to the private water-works plant; it must be careful from the point of view of valuation of the effect of this arrested development and of the effect of not building at all during the higher-price period. These works will ultimately be valued on the basis of the cost to them of rendering the service. They will be in a safe position financially if they have gone ahead with your problem, if they have records of the present-day costs, as well as of pre-war costs. A very grave injustice will be done to them, on the other hand, if pre-war costs are used as the basis of valuation or rate determination, under present or future conditions.

President Macksey. The main thought in the paper as read by Mr. Eldredge has been discussed now, while not at great length, certainly very thoroughly.

The thought came to my mind after listening to the discussion, of what effect the laying of small mains has on insurance rates, and in this connection it would be well for every superintendent to get a copy of the detail sheet showing him how he has been rated by the underwriters. I have no doubt that the underwriters have tried to be perfectly fair, and in many cases they did very thorough work, but they cannot always do perfect work, and there are many times when a discussion of the details of their rating would show that they have charged up against the water department deficiencies which are not justified. I am inclined to think, too, — but it is only an impression which I am unable to prove by figures,

— that the insurance man's wild fear of a conflagration is making many an honest man pay hundreds of dollars year after year when he has no risk. That is something that we water-works men cannot prevent.

There is another side to this fire protection. A man builds a factory in a city where the municipality owns the works. Of course the taxpayers want the city to grow. They want new factories; they want their local men to invest their money at home and employ local people — they want to do all of these, and thought the factory might be properly supplied with a 1-in. pipe. But in order to compete with others he must have insurance; in order to compete with others he must get the most favorable rate; in order to get the favorable rate he must have hydrants and sprinklers. The sprinkler man demands a 6-in. connection to the sprinklers. I have recently put in connections to factories in order that they might have the required fire protection, not to prevent the destruction of their works, because in these cases if a fire starts, sprinklers will not stop it, but in order that that owner may get an insurance rate which will let him do business profitably. The water works of the city invests a thousand dollars in each of those services. There is still another case where, if the main is not laid now, with three feet of frost in the ground, the owner, and men who wish to work for him, must endure great hardship. There are loads put upon water works which consumers do not allow for, when told, " Your water rates must be increased."

If the water department is concerned not solely with supplying water for domestic consumption, not solely with supplying the necessary water for fire protection, but supplying what is necessary to prevent the underwriter from swinging a heavy club on the ambitious manufacturer, somebody besides the man who is buying water for domestic use should pay the cost of each of such installation as maintenance of service. [*Applause.*]

THE EFFICIENCY OF PIPE JOINTING COMPOUNDS AS COMPARED WITH LEAD.

FRED O. STEVENS.*

[*Read March 10, 1920.*]

The great difference in cost between lead and the non-lead joint materials makes it an obligation on the part of water-works engineers and executives to satisfy themselves as to the efficiency of the non-lead products. Although these materials have been in the market for about sixteen years, and have been used in increasing quantities during that period, they are still regarded by the great majority of water-works men with more or less skepticism.

The facts of the case are that lead has proved to be such an excellent material for joints, and workmen have become so well trained in its use, that engineers and superintendents have naturally and rightly hesitated to substitute for it a substance with which they are unfamiliar, and upon which there is a relatively small amount of data as to its efficiency.

The writer has used the two substitutes known as "Leadite" and "Lead-Hydro-Tite" for over eight years, in various localities and under varying conditions, with very satisfactory results, and as a consequence has acquired a great degree of confidence in them. The water-works profession, however, must be, from the very nature of its work, very conservative in adopting untried methods and materials, and is bound to demand something more than the testimony of a few of its members that a certain thing "works all right, as far as they know."

The purpose of this short review, then, is not to take a partisan stand in favor of any joint material, but to impress upon the members of the Association the fact that these substitutes for lead are worthy of careful consideration and investigation in view of the present prices of lead and labor. It is to be hoped that a general discussion may bring out some new facts and stimulate further investigations.

To the manufacturers the writer would suggest that, having now established the comparatively low cost of their products in the minds of the water-works trade, they devote more energy to experimental work, to enable them to answer with definite figures the questions to which a thorough and thoughtful water-works man must have an answer before making what would otherwise appear to him a hazardous change.

The most important of these questions are as follows:

(1) How do joints of these materials compare with those of lead as to tightness under normal conditions?

* Engineer and Superintendent of Water Works, Weymouth, Mass.

(2) What of the possibility of blown joints under high pressure due to water hammer, etc.?

(3) Will the joint have sufficient strength to resist stresses due to bending moment when support is removed from a considerable length of pipe as a result of settlement of back-fill or nearby excavations for services, etc.?

On the first question the writer is able to submit evidence derived from actual experiment. In the summer of 1917 the Weymouth Water Works laid 3 400 ft. of 8-in. pipe, from which no services were taken until the following season. The joints were of Lead-Hydro-Tite, and the new gate controlling this line was by-passed with a 5/8-in. Empire meter testing 99 per cent. in 1/32-in. opening. For the final measurements the flow was too small for accurate measurement by meter, and a force pump was used, pumping from a pail into which water was fed by a standard gallon measure. The results as to leakage per linear foot of joint are shown in the following table, and would, according to available data on the subject, be considered excellent for lead joints.

Tests for Leakage from Lead-Hydro-Tite Joints, Idlewell Extension, North Weymouth, Mass.

Date.	Section.	No. of Joints.	Gals. per Minute.	Gals. per 24 Hrs. per Lin. Ft. of Joint.	
1917.					
July 26	1	75	3.375	26.20	New joints.
*Aug. 8	1	75	.150	1.16	
Aug. 20	2	180	.322	1.04	Sec. 1 plus 105 new joints.
Aug. 25	2	180	.305	.99	
Sept. 29	2	180	.217	.70	
Nov. 2	1	75	.041	.32	
Nov. 2	2	180	.098	.32	
Nov. 2	3	250	.495	1.15	Sec. 2 plus 70 new joints.
Nov. 2	4	335	3.500	6.16	Sec. 3 plus 85 new joints or entire extension.
1918.					
*June 1	4	335	.150	.26	

Pipe was 8-in. Class E., New England weights. Average pressure, 70 lbs.
Leakage measured by 5/8-in. Empire meter, registering 99 per cent. on 1/32 in. opening at 70-lb. gage pressure.

* By pump and gallon measure.

This work was done by a man having one season's experience with Leadite, exercising the ordinary degree of care usually required by the writer on this class of work, and the results should give a fair indication of the degree of tightness to be expected under average conditions.

As to the matter of joints blowing out, the writer can only say that he has never known of a Leadite or Hydro-Tite joint blowing out. In fact the strength of these materials and their adhesion to the metal as demonstrated when a joint is dug out seems to be sufficient evidence of their safety in this direction without extensive experiment.

As to the behavior of this type of joint when subject to crushing stresses such as occur when portions of a pipe line are left unsupported by the settlement of backfilling, the writer has been, until very recently, in doubt; in fact, uncertainty on this one point has prevented him from giving these materials his unqualified endorsement as substitutes for lead. This doubt has been pretty much dispelled by the results in a case that has recently come to his attention.

The Berlin Water Company, of Berlin, N. H., built last year a new dam from which an 18-in. cast-iron main was to lead to the city distribution system. About two lengths of this pipe were in the dam, and on the end of the first length on the down-stream side an 18-in. valve was placed. Joints were all of Lead-Hydro-Tite. Before any more pipe was laid the reservoir was filled, and some time later a washout occurred which completely undermined this length of pipe, leaving it and the gate suspended in the air and supported solely by the material in the joint near the masonry. Just what the maximum stresses were in the joint it is neither easy nor necessary to compute, but it seems to the writer that they are as great as are apt to be encountered under ordinary working conditions.

The writer has not attempted to take up the methods of using these compounds, or the minor difficulties attending their use for the first time with inexperienced men and incomplete equipment. These points have been covered in previous papers before the Association and in the literature with which the manufacturers keep us abundantly supplied.

It does unquestionably require considerable courage and considerable faith to give up the good old lead and substitute these new materials in the face of the inevitable opposition from calkers and doubt as to the outcome of the first day's work. The point that the writer wishes to make and to urge very strongly, however, is that we water-works managers and engineers cannot, with a clear conscience, go on using and specifying lead, if these other substances are safe and suitable substitutes. And it is "up to us" to find out whether or not they are safe and suitable, or to make every possible effort to find out.

The bulk of the evidence, so far, all points in one direction, — in favor of the substitutes. In the discussion that is to follow, let us hear from the other side, — the unsatisfactory experiences which, for our present purpose of getting at the truth, are perhaps the most valuable of all.

Discussion.

E. E. Wall* (*by letter*). The St. Louis Water Division has on several occasions tried other materials than lead for making cast-iron pipe joints The first experiment, of which no record was kept, was made in 1907, although it is remembered by old employees that experimental joints were run with some patent compound before that time, which presumably proved unsatisfactory, as no record was made of their cost or efficiency, and no further consideration was given that material.

During the year 1913 a line of 6-in. pipe was laid in Fair Grounds Park, a connection being made to the city main in Natural Bridge Road, west of Grand Avenue. The pressure at this point is approximately 35 lbs.

The joints on this particular line were made with Leadite, and so far as reported, have not given any trouble nor has the line required any maintenance since it was laid. The use of Leadite was purely an experiment, and it was thought at the time, after trial, that it would not be easily adapted to local conditions.

Leadite is a material which requires a very definite heat for melting to proper consistency, and it was found difficult, if not impossible, to control the temperature by means of a coal fire built around a melting pot as was used on pipe-laying work at that time. The tendency seemed to be to have the fire too hot, which caused the Leadite to burn. Trouble was also experienced by the men pouring the joints, in that the fumes would rise from the pouring pot directly into the faces of the men. This condition seemed to be particularly bad by reason of the fact that the trench in which the pipe was laid was narrow and deeper than the ordinary trench for 6-in. pipe.

Unfortunately, no figures were kept on the cost, but there seems to be no doubt, but that if properly used by experienced men the cost could be reduced below the cost of the ordinary lead joint.

Joints made of Portland cement were used on about 800 ft. of a 6-in. pipe line laid in 1917 to supply Camp Galliard, a temporary recruiting station for a regiment of engineers, afterwards the 312th Engineers.

From the 12-in. main for a distance of about 150 feet, the 6-in. pipe joints were made of lead, because the pipe was crossing a highway and also passed under the track of the water works railway, and it was assumed that any and all vibration or shock would be less liable to produce leaks with lead joints than with more rigid ones made of cement.

The cement joints were made by employees, who had formerly had experience in such work for the gas company, who have laid all of their smaller mains here for years with cement joints.

No leaks developed, and the joints showed no deterioration or checking when the line was taken up a year later. The water pressure ranged from 90 to 120 lb. per square inch.

* Water Commissioner, St. Louis, Mo.

It was found that one bag of cement made 18 joints, and each joint required twice as much jute as a lead joint. Three men mixed and made 8 joints per hour.

Two men can attend to lead pot, make rolls, run and calk ten 6-in. joints per hour.

Actual cost of making 66 joints of cement in 1917:

4 sacks cement @ 43¾c	$1.75
16½ days' labor @ $2.42	39.93
8¼ days' labor @ $2.10	17.32
82½ lb. jute @ 8c	6.60
	$65.60

Estimated cost of making 66 joints of lead at 1917 prices:

792 lb. lead @ 7c	$55.44
$6\frac{3}{5}$ days' labor @ $2.42	15.97
$6\frac{3}{5}$ days' labor @ $2.10	13.86
41¼ lb. jute @ 8c	3.30
	$88.57

Cost per joint — Cement, 98c.
Lead, $1.34.

Cost per lineal foot of pipe — Cement, $8\frac{1}{3}$c.
Lead, $11\frac{1}{5}$c.

When this line was taken up in 1918 it was found to be much more trouble and expense than taking up pipe laid with lead joints. The method finally adopted was to place a strong iron collar back of the bell of the end pipe, so that jacks could be placed on the sides of the pipe to operate between this collar and the bell end of the next pipe. The cost of taking up this pipe line was 9.7c., while the cost of laying was 5.7c.

In 1918 about 1 200 ft. of 6-in. pipe was laid, the joint being poured from a new compound called "Metalium." After the pipe was laid the trench was left open for about two weeks to note the leakage, which was measured through a small meter. This leakage, immediately after the pipe was laid, amounted to 2½ gal. per minute, the average during the first twenty-four hours being 1.3 gal. per minute, which was reduced to an average of 1.15 gal. per minute during the second twenty-four hours. In the course of the two weeks before the trench was filled the leakage stopped altogether.

Joints made of this compound did not in this case prove to be as cheap as those made of lead. This may be due to the fact that our men were unfamiliar with handling the material. The indications are that the difference in cost between Metalium joints and those made of lead would be too small to make it any great inducement to us to use the compound on a large scale.

The last three lengths of pipe laid on this line were laid on a sharp up-grade, the rise being 3 ft. in 36 ft., the change in grade being made at one joint. Afterwards this pipe was lowered while under pressure and this joint was closely watched during the process of lowering, but no leakage was noticed and no damage to the joint was observed.

For fifteen years milk of lime, at a temperature ranging from 80 to 130 degrees Fahr., was pumped through a 6-in. cast-iron pipe from the coagulant house to the delivery well, a distance of about 700 ft.

A great deal of trouble was experienced with leaking joints caused by expansion and contraction. In 1919 a new line was laid with cement joints.

The joint was calked with yarn, as in a lead joint. Cement was mixed neat, rather dry, and tamped in the joints by means of a calking tool. The calking was carefully done, and continued until water came to the surface of the cement joint. The joint was continued on the outside by being built up to the outside diameter of the bell of the pipe and sloping down to the barrel of the pipe at an angle of about 45 degrees. This was troweled to a smooth finish, neat cement also being used.

This line has been in service for several months, and has given no trouble on account of leaking joints.

The only leak that has occurred on the line was found on examination to be due to a transverse break in the pipe about 18 in. from a joint. The pipe was pulled completely in two, the nearest joint being entirely intact and uninjured. Evidently the break was due to contraction in the line caused by temperature change.

Mr. R. C. P. Coggeshall.* We laid some short sections of the pipe in New Bedford, with joint compound, and to my knowledge there has been no difficulty with it; therefore it has been pretty satisfactory. This coming year it is proposed to do considerable work there, and Mr. Taylor, my assistant, has taken up the question of the adoption of Leadite in preference to the lead joints, and I think is ready to adopt it. I think perhaps it would be interesting to hear what his plans are in that regard.

Mr. Stephen H. Taylor. I plan to make some experiments with practical joints before deciding what to do. We have not yet made those experiments, but hope to in the future. That will demonstrate the efficiency or the inefficiency of the joint to us.

Mr. Lincoln Van Gilder.† In the old days, when the Atlantic City Water Department was run by two different franchise holders, all joints were laid with lead, but about 1901 Mr. William C. Hawley, now in Wilkinsburgh, Pa., began the use of Leadite. He was followed by Mr. Allen, his successor, and by myself. We now lay with Leadite almost exclusively. We have had no difficulty in carrying pipe along trench lines, and as our contractors are not always careful, the pipe gets pretty heavy punish-

* Superintendent of Water Works, New Bedford, Mass.
† Superintendent Water Works, Atlantic City, N. J.

ment. We have no difficulty with the Leadite joints. The first joints laid with Leadite, back in 1901, are still intact and do not show any signs of deterioration.

Mr. Frank A. McInnes.* For what it is worth I will give you one experiment that we made ourselves. Four lengths of 4-in. pipe and one short piece were jointed with Leadite, supported at three places, — at each end and in the middle. The center support was removed and a deflection of 22 in. followed without leakage, with no sign of failure of the joints. We then proceeded to load the center of the pipe. At a load of 100 lb. no leakage had developed, when the pipe suddenly broke in two in the middle, at a point 18 in. distant from the nearest joint, and where a 5/8 tap had been taken out of the 4-in. pipe and plugged with a cast-iron plug. At the time of the break there was a total deflection of 25 in. The span from support to support was about 48 ft.

That encouraged me to use Leadite in laying pipe on a bridge across the Neponset River. This bridge carries heavy traffic, including two lines of heavy cars. The necessary location for our pipes was within approximately 4 ft. of one of the rails, and about 3 ft. lower, on a part of the bridge where it was subject to serious vibration. We used Leadite. That experiment is still in process. It has been there for five months now. When the line was put in we had leakage — not serious leakage, but continual dripping. Before the pipe was covered up in order to protect it from frost, that leakage had nearly ceased, and subsequent examinations appear to show that it has altogether ceased. Owing to the snow conditions we have not been able to see it for the last month.

Mr. John Doyle.† The city of Worcester has had some experience in this respect. Last summer we laid about 500 ft. of 12-in. pipe with Leadite, with very good success. We have not had a leak on it, as far as I know, since that time. We also use Leadite on the services. So far, I cannot say anything but praise for it.

Mr. Frank J. Gifford.‡ There is one very important thing in connection with the pipe-jointing material, and that is the ability to carry current for thawing purposes. I should like to know what the experience has been of Mr. Stevens, in thawing services — not the main pipe, but carrying current enough to thaw services.

Mr. Stevens. I will say that I have had a little experience in that line, and that Leadite is an excellent insulator. I have to state frankly that I can't get an effective thawing current through it. I have heard it suggested, that if you wish to overcome that you should introduce a little wedge of lead in every joint. I never tried any such thing.

Mr. George McKay, Jr.§ I think the Boston Water Department has made an experiment in thawing services, and they experimented

* Engineer Public Works Department, Water Division, Boston, Mass.

† General Foreman Water Department, Worcester, Mass.

‡ Superintendent Water Works, Dedham, Mass.

§ Of the Leadite Company.

with a lead wedge in the bottom of the joint, to see if they could get current through the service pipes, and discovered later on that they did not need to use the lead wedge. Leadite in itself is a very good non-conductor of electricity, as Mr. Stevens has said, and if you can insulate the spigot end from the hub to the shoulder you will have in time an insulated joint as nearly as possible. But quite frequently the spigot end comes up against the hub, and that would make a connection. But in getting current through the line you do not have to depend on that. For electrolysis you want to make your joint as nearly non-conductible as possible, and for that reason you will reduce your trouble with electrolysis. But usually your electrolysis difficulty is a very low voltage. In thawing out mains I understand the best results are obtained by keeping your voltage down to about 10 volts, and having your amperage at from about 225 to 300 amperes. We know that water in itself is a poor conductor of electricity, but yet you can get sufficient current through it to thaw out your services. That thin film of water will allow your current to pass through. I know that the Trenton Water Department during the winter of 1917–18, which I believe was the very severe winter, had 2 000 services frozen up, and I asked Mr. Bugbee if he ever thawed any lines on which the joints were made of Leadite, and he said, "Yes." I said, "Do you ever have any trouble in getting current through it?" He said, "No." They have had quite a good deal of Leadite in their system.

Mr. Stevens. That may be a question of amperage. We used a voltage of 110, an amperage of about 200.

Mr. McKay. Your voltage was too high. You should keep it down to 25 and you would not have any trouble.

Vice-President Brush. What size pipe do you use the Leadite on, Mr. Van Gilder?

Mr. Van Gilder. All sizes, from 2 in. to 24 in.

Mr. Gifford. I should like to know if any one has used that wedge, either of lead or other metal. Personally, the theory of the water conducting the electricity does not appeal to me. I have a lot of cement-lined pipe, and I know that the water won't carry very much electricity. We also have a shell of wrought iron that is butted up in the same way the previous speaker spoke of, which will not carry enough electricity to get much voltage or amperage. And if any one has used the metal wedge I should like very much to hear about it. I am interested in some substitute for lead, but I am very much interested in the thawing proposition. I think that is very essential.

Mr. A. E. Martin.* We use the lead wedge in Springfield, but I can't tell you whether we get the current through it or not. We have not had occasion to use it. Before deciding to use the lead wedge we laid half a dozen lengths of pipe together in the yard, with the calking yarn in the joints, pulling the pipes just far enough so that they would not touch

* Superintendent Water Works, Springfield, Mass.

in the bells. We could not get any current, of course, through those pipes without some conductor at the joint, but when the wedge was put into the joint we could get the current through, and considered from that that it was easy enough to get the current through the pipe if you put the lead wedge in. So we are using the lead wedge. We bury our pipes in Springfield now, so that we hope not to get any frost in them, but have not had experience yet, so that we can tell. We have just got an electric thawing machine and had occasion to use it twice this winter, and could have used it two or three times more but the snowstorms buried us up so deep we couldn't get it out of the city.

Mr. Coggeshall. How deep do you lay your pipes now?

Mr. Martin. Not less than 6 ft. deep, with 5½ ft. cover. That carries the service pipe down, with a little dip at the main, 6 ft. We bury all the service pipes 6 ft. deep. We have not had any experience yet that would indicate that it will not protect us from freezing. There were one or two instances two years ago where the frost went down 7 ft. deep, but those were exceptional.

A Member. I should like to ask if there was water in that pipe when you tried to get the current through?

Mr. Martin. No; it was dry.

Vice-President Brush. I should like to ask what size lead wedge you used.

Mr. Martin. Just a small wedge, about 2 in. thick and 2 in. wide.

Mr. McInnes. I regret that I am not as familiar as I should like to be with just exactly what we did and what results we got. The same thing troubled me that has been bothering Mr. Gifford, but we have had no trouble at all in carrying current through the pipe laid with Leadite, nor have we had any trouble in carrying current from the main through the branch to the hydrant in at least three cases. We made the same experiment that Mr. Martin has told us about with a 4-in. line in the yard. Before we laid and put it in service we found out enough to know the conditions. But I personally did not make a study of that. I am pretty sure that we are satisfied with our use of Leadite.

Vice-President Brush. Mr. McInnes, what pressure did you have on that 40-in. line in the yard?

Mr. McInnes. Fifty-five lb.

Mr. McKay. Speaking of pressure, I had an interesting thing happen in the office, a couple of weeks ago. A gentleman from Bluefield, W. Va., said that they had been using Leadite for about twelve years, and were going to use it under 140 to 200 lb. pressure in a line they were about to put in. That aroused my curiosity. I said, "What is the highest pressure you have where you are using Leadite?" He said: "350 lb. On one line of this 350 lb. pressure, which is a 10-in. line from the pump, the pipe was originally laid with lead, and it hung over the edge of a creek, where the earth was cut out from under the pipe. Every once in a while

it would work out, and we would have to shut down the pressure, jack it back in place, and brace it up again; but finally we thought we would try Leadite on it. We put it in with Leadite and it is still there, and under 350 lb. pressure at the pump."

MR. ROBERT S. WESTON.* We analyzed one of these preparations at one time, and we found it contained some, as I remember, 22 per cent. of iron filings, which ought to make it something of a conductor.

MR. GEORGE H. FINNERAN.† In Boston, after our experience with frozen pipes during the winter of 1917–18, we realized our dependence upon electricity as a means of thawing. As we had been using Leadite somewhat and had arrived at a point where we intended to extend its use, it occurred to us as desirable to know whether or not Leadite joints prevented the passage of electricity on our pipe lines. As a means of answering that question we assembled on blocking in our yard a section of 4-in. cast-iron pipe about 50 ft. long, containing about seven joints. Caps were placed on both ends and water admitted to the pipe under pressure. Corporation cocks were placed in the line at points between the joints. Connections were made with these cocks and a storage battery of eight 2-volt cells connected in series. Volt meter, ampere meter, and other necessary apparatus were used, but not the slightest indication of a flow of current through the joints could be observed. We then burned out the joints and re-made them, inserting in several a lead wedge about 2½ in. long, 2 in. wide, and ½ in. thick. The wedge was placed in the bottom of the joint and driven in so as to make contact between the bell and spigot, and the Leadite poured around it. Electrical connections were made, and we found that a flow of current passed through every joint which contained a lead wedge, but not through those without it. We allowed the section of pipe to remain under pressure for two weeks, and upon again testing the joints electrically, we found the conditions to be the same. As to the amount of current flowing on the pipe, it varied from 1 ampere to 400, and from 14 volts to 30. This amount of voltage and amperage was made possible by using 16 cells in our battery. No bad effects were observed in the joints during the flow of 400 amperes, other than the heating of the lead wedge to the point where it caused the surrounding Leadite to melt a very little. This could have been avoided by using a larger wedge. We next decided to make tests on pipes in the ground where we knew Leadite was used in the joints. We applied the current exactly as we would in an actual thawing job, with the following results:

At the intersection of M and Eighth streets, where a 12-in. gate had recently been established on the Eighth Street line, four Leadite joints were used. By connecting our positive terminal with the service pipe in the house located in M at Eighth Street, and our negative terminal with

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* Of Weston & Sampson, Boston, Mass.

† Superintendent Water Service, Boston, Mass.

the pipe in the house located in Eighth at M Street, the current traversed by way of the pipes about 50 ft. of 5/8-in. lead pipe with brass fittings, 72 ft. of 6-in. cast-iron pipe with lead joints, and 36 ft. of 12-in. cast-iron pipe with four Leadite joints and three 12-in. lead joints. Under these conditions a flow was obtained which our meters indicated as 110 amperes, 16 volts. The soil in the vicinity is clay. We could have increased the flow by increasing the voltage, but we considered that which we obtained sufficient.

In Dudley Street, near Belden Street, we made connections with the supplies to two houses 100 ft. apart. The Dudley Street main is 12 in. diameter and jointed with lead except where a 12 by 6 hydrant branch had recently been inserted and Leadite used in the joints. This hydrant branch was located between the two services. By using 16 volts we obtained a flow of 87 amperes. Car tracks are laid in Dudley Street, and at this point one of the rails is about 3 ft. from the line of our main pipe. By transferring our negative terminal from the service pipe to the car rail the flow increased to 100 amperes. In my opinion, this indicated that the current, after traversing the service pipe to which the positive terminal was attached and the main pipe as far as the Leadite joints, jumped from the main pipe to the rail and followed the rail to the negative terminal, thus indicating less resistance in the soil between the main and the rail than in the main and the Leadite joints. Our experience in electrical thawing is that the soil very often acts as a good conductor, and where a hydrant or service pipe was not conveniently located for contact with our negative terminal, and a car rail was laid in the street, we always used the car rail as the negative electrode with usually satisfactory results.

In Assabet Street, Dorchester, where we laid 161 ft. of 8-in. main and established a post hydrant in 1910, using Leadite for joints, a flow of 215 amperes pushed by 16 volts was obtained between our two terminals. The positive terminal was connected with the sill cock of a house, and the negative terminal was in contact with a post hydrant. The distance between the two terminals by way of the pipes was about 160 ft., of which 123 ft. was 8-in. cast-iron pipe with Leadite joints, the remaining portion being 8-in. cast-iron pipe with lead joints, and 5/8-in. lead pipe with brass fittings. The ground was loam, quite moist, being at the bottom of a hill. Thinking that the soil might be a big factor in the flow, we cut out and removed from the ground a section of pipe containing a Leadite joint, and tested it for a flow from the bell to the spigot. We found a free flow, but upon further testing and closer inspection we discovered that the current traveled through a film or scale of what appeared to be rust which had accumulated on the face of the Leadite joint. When this scale was removed — and it required some vigorous cutting and scraping to remove it — the current ceased to flow. We then removed the Leadite from the joint and tested it for conductivity and found that the clean, uncombined Leadite would not carry current, but that combined with the scale

which adhered to its surface it became a conductor through the medium of the scale.

The conclusions arrived at through these and other experiments are that a Leadite joint by itself is a non-conductor of electricity; that cast-iron pipe lines with Leadite joints can be made to carry a current of electricity by the insertion in each joint of a metallic wedge, preferably of lead, of sufficient size and so placed between the bell and the spigot as to make good contact; that under certain conditions Leadite joints will not prevent the passage of a current of electricity along a cast-iron pipe line, as, for instance, where a rusty scale is developed on the face of the joints, making a path for the current from the spigot to the bell, or where the spigot butts against the bell and contact is made complete by the lodgment of rust between.

As a general statement based upon conditions as they exist in Boston, it is safe to say that in almost every case the soil will act as a conductor and offer a path for the current either around the Leadite joints or in some other way to the negative terminal; and that the use of Leadite as a joint-making material will not interfere with the use of electricity as a thawing agent.

DESCRIPTION OF MOTOR-DRIVEN PORTABLE THAWING MACHINE MOUNTED ON TRUCK.

BY FRANK J. GIFFORD, SUPERINTENDENT OF WATER WORKS, DEDHAM, MASS.

[*Read December 10, 1919.*]

Every water-works man who was in charge of a plant during the winter of 1917–18 is at this time probably anxiously watching the thermometer, and reading the latest predictions of some weather prophet with a local reputation.

Those of us, especially in the smaller plants, who had to personally supervise every detail of the thawing of frozen pipes as well as to hear the complaints of and pacify the irate householder because we had allowed his service pipe to freeze, have been trying to devise some economical and effective method of thawing.

It was the privilege of the writer to serve on your "Committee to Investigate Conditions in Water-Distribution Systems, Arising from the Severe Cold of Winter of 1917–18." This committee collected considerable data and information on the subject of thawing, methods, costs, etc., which was presented to the Association, September 11, 1918. Several types of thawing apparatus were described, some of which were in actual use, and others suggested as practical. Based upon the information obtained in the preparation of this report, the writer has formed the opinion that current as used for thawing purposes on small pipe lines has been at too high a voltage, involving more power for generation than necessary, as well as possible danger of damage to services and fittings.

The outfit which I am going to describe to-day was not mentioned in the report, but was developed from those suggested, combined with an old motor truck which our company had discarded early in 1917. In working out the present design, we have aimed to use reduced voltage and to discover some of the limitations in this direction.

The writer wishes it understood at the outset that he is not overburdened with electrical knowledge, but is fortunate in having a meter inspector who has a working knowledge of electricity and good mechanical ability. I wish to give Walter G. Hoffman, our meter inspector, full credit for the development of the ideas, as well as for all the labor necessary to perfect and complete the outfit.

The apparatus is mounted on a one-ton Koehler truck. This truck is a 1914 model, with two-cylinder motor rated at 24-horsepower. In our development of the unit, we discovered that the official power rating of an automobile engine is not the output that can properly be depended

upon for continuous-load service, and we have arrived at an output of about 15-horsepower as about right for endurance limits. (Fig. 1.)

The engine is suspended below the frame and partly under the driving seat, the fly-wheel being located about one foot to the rear of the seat.

It is due to this type of construction that we were able to develop the machine as it is to-day.

Having the truck, our problem then was to find a generator which we could run with the limited horsepower which was available and develop sufficient voltage and amperage. A second-hand C & C generator was

FIG. 1. TRUCK FOR THAWING OUTFIT.

located, — 2-pole, 125 volts, 16 kw. In its original form, this generator would develop more voltage and less amperage than desirable, particularly in making best use of the limited power available, and accordingly we had the windings rearranged for 55 volts.

In this connection, it was necessary to cut out the mica between every other segment and fill with copper. Doubling the width of the segments made it necessary to have brushes twice as thick as the old ones. Carbon brushes of sufficient thickness, made especially for this job, were tried. After testing we had to discard them, as we were unable to develop any current with this type of brush.

Copper brushes finally solved our problem. These were used by doubling up two commercial size brushes and making special brush-holders.

The generator is mounted on a frame made from 2 in. by 8 in. hard-pine planks and set with the pulley on the drive shaft directly over the fly-wheel of the engine. The fly-wheel and pulley are connected by means of an endless leather belt 5 in. wide. This belt hangs loose from the generator pulley when the engine is running idle or when truck is running between jobs.

The fly-wheel of this particular engine is 16 in. in diameter, and, having no means of determining how fast it was traveling, it was necessary for

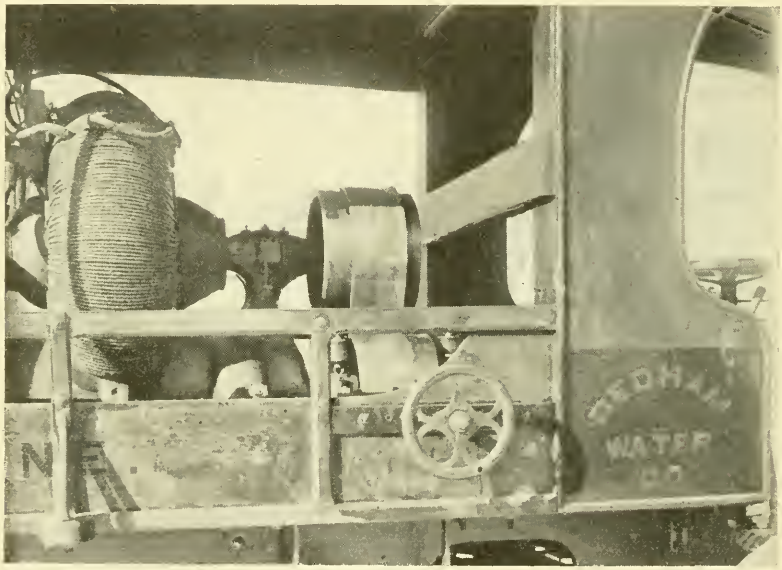

FIG. 2. HAND WHEEL FOR TIGHTENING BELT.

us to experiment, after getting connected up to determine the proper size pulley for the generator. A 12-in. pulley with 8-in. face was finally decided upon as being the proper size.

To transmit power to the generator when ready to begin thawing, the belt is tightened by means of an idler pulley mounted on wooden slides, connected by a screw operated by a hand wheel on the outside of the truck body. Attached to the shank of the screw just inside of the body is a ratchet-wheel on which a pawl is dropped to prevent screw from backing out, because of vibration, and loosening the belt when machine is working. (Fig. 2.)

Next to the generator, and mounted on the same wooden frame, are two wooden spools, acting independently of each other, each carrying 250 ft. of 4/0 copper wire. These spools are made with an axle shaft of $1\frac{1}{4}$ in. pipe. The inner end of the wire passes through the drum and into the shaft through a hole cut in the side, coming out at the end which projects

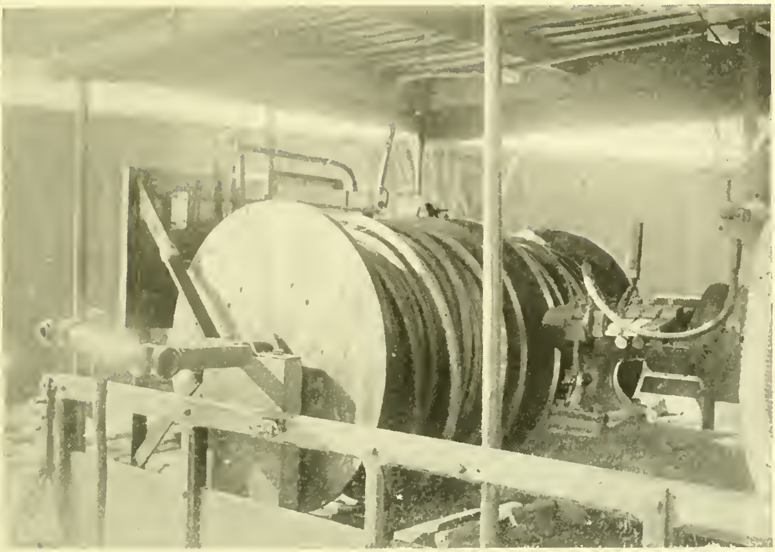

FIG. 3. SPOOLS OF 4 PER CENT. COPPER WIRE SHOWING WINDING CRANK.

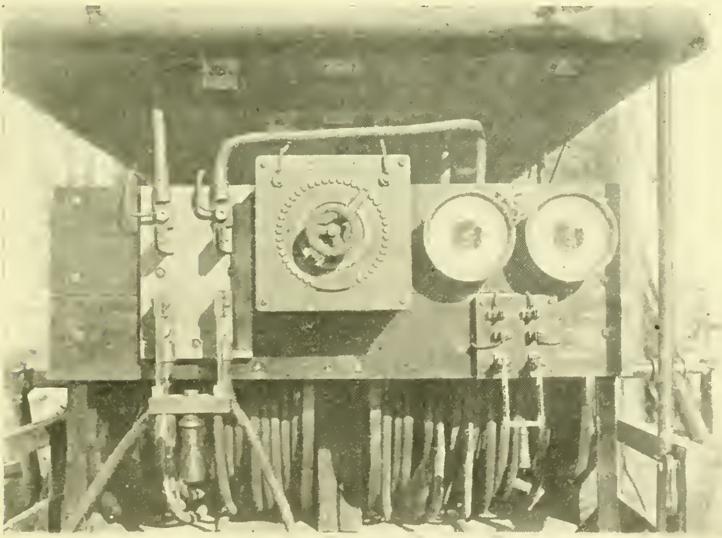

FIG. 4. SWITCHBOARD, RHEOSTAT, VOLTMETER AND AMMETER.

over the side of the truck. Here connection is made with the lead wire from the generator by means of a wing-nut.

A tee is made on the end of the axle shaft into which a handle is screwed so that the wire may be readily reeled up after use. (Fig. 3.)

At the rear of the truck, and on the frame which carries the generator and reels, is the instrument board. On this board is mounted the main

switch, a rheostat, an ammeter, a voltmeter, and a small switch which controls the lighting circuit. Five lamps have been installed on the truck for night work. (Fig. 4.)

Much experimental work was necessary before we were satisfied that we had an outfit that was practical. One of our first obstacles was to develop the maximum power of the engine and prevent excessive heat and boiling of the water in the radiator. At first we attached an auxiliary tank of water to the radiator. While this stopped the boiling to a great

FIG. 5. TESTING APPARATUS.

extent, the engine did not furnish all the power and speed we desired and which we thought it capable of developing.

The ignition was then investigated, and we found that our magneto was operating with a fixed spark, not far enough advanced to give us maximum speed. The magneto was removed, and six dry-cell batteries with a two-cylinder timer and spark control lever, substituted. This change gave us the desired speed, and also allowed us to remove the auxiliary water tank.

The final result obtained was to develop 230 amperes at 27 volts. This amount of current we figure will be sufficient for our work, although we are hoping that we will never have to use the outfit.

Our experiments were made with the full amount of wire carried on the truck in use and with water resistance. (Fig. 5.)

I regret very much that I am unable to give you the exact cost of the outfit as it stands, as all the labor was performed by Mr. Hoffman when he could spare an hour or two. No record of this time was kept.

Much of the material used in the construction was discarded material such as can be found around any water-works plant.

The largest item of expense was the generator. This, together with the switches, rheostat, ammeter, and voltmeter, cost $150. The expense of rewinding the armature was $90. Other material which we had to buy, including wire, amounted to approximately $235.

Discussion.

Mr. J. M. Diven.* What we are looking for is some self-contained apparatus at a moderate cost. That cost, I should say, should be within a thousand dollars, to be available to the smaller water works; that is, the gasoline engine, and so forth, which could be mounted on skids that could be run out in wagons or sleighs, for instance. Sometimes in the northern part of the state of New York they have frozen services when there is three or four feet of snow on the ground. It would be rather difficult to operate a truck under those circumstances. Of course he did not estimate the truck, and in buying a new truck we would find the cost prohibitive, because probably a one-ton truck would cost fifteen hundred to two thousand dollars, anyhow, if purchased now.

Mr. Gifford. We had thrown that truck away, and it was discovered and resurrected.

Mr. Diven. We are still in hopes that somebody will devise and manufacture an apparatus costing within a thousand dollars that will be self-contained, and that can be stored away, mounted on any truck.

Formerly, the shut-offs to services were located at the mains, and during the year 1917–18 we wished they had been there.

Another great difficulty any thawing apparatus would not reach is what they call "sub-laterals," put in before the street is paved. There were some fifty-odd of those in the city of Troy that were frozen, burst, and had to be taken out during that cold winter.

Mr. Reeves J. Newsom.† I should like to ask Mr. Gifford if he has any data as to the probable amount of current required in thawing the ordinary services. Whether that has been determined as the result of any test you have made on this.

Mr. Gifford. All I have to say on that is that the committee report in 1918 contained that.

Mr. Newsom. I have developed a self-contained outfit along these same lines. I can't give much information as to the cost, or much hope that it will cost a very small amount; but I succeeded in locating a 6 by 6

* Superintendent, Water Works, Troy, N. Y.

† Commissioner of Water Supply, Lynn, Mass.

marine type engine, which is capable of delivering in excess of 25 h.p. In connection with the generator designer at the General Electric Company in Lynn, after talking over many schemes for making up such an outfit as this, we finally decided that the generator which was used recently for furnishing power to these large searchlights would be about the proper thing to hook up to an engine of that sort. I discovered, as the author of this paper did, that the voltages that had been used were too high, and we rewired this generator so that it would give about 55 volts, and we also found that in order to put out large amounts of amperes copper brushes would be required. We have mounted the entire apparatus on two steel I-beams, and the generator is directly connected to this engine and can give us in the neighborhood of 500 amperes, 50 volts. We are just now ready to start making some experiments as to what is required for different sizes of services, and whether or not small mains can be thawed with an amperage of that amount with a voltage of 50. We have hopes that it may be fit for not only all kinds of services but small mains and dead ends that give us trouble.

Mr. Gifford. I think the committee found that thawing ordinary $\frac{3}{4}$-in. services required 175 amperes, taking about six minutes.

Mr. Newsom. At what voltage?

Mr. Gifford. About 30 or 32 volts, I think.

Mr. Frank L. Fuller.* I should like to ask Mr. Gifford if this truck is in ordinary use or whether it is kept with this apparatus permanently attached?

Mr. Gifford. The apparatus is attached on 2 by 8 skids. We can slide it out. We have no use for the truck.

Mr. Morrison Merrill.† I should like to ask Mr. Gifford if he has had any experience with alternating current in thawing.

Mr. Gifford. Only as used from the electric-lighting system.

Mr. Merrill. Did you notice any particular features regarding the alternating current?

Mr. Gifford. I do not know as I understand just what you mean by the "features."

Mr. Merrill. What I mean is that I never have used direct current in thawing, but I have used the alternating current a great deal; in fact, I had charge of the thawing out in Wakefield. And I noticed there was quite a vibration, either on large or small service pipes, from two inches down, caused, I presumed, by the alternating current. I was wondering whether it had anything to do with improving the thawing properties of the current. If you put your hand on the pipe you can feel the vibration, which you won't get with the direct current.

Mr. Gifford. I do not know as I can answer that question, Mr. Chairman. I think an electrician will have to answer that.

* Civil Engineer, Boston, Mass.

† Superintendent Water and Sewer Department, Wakefield, Mass.

President Killam. Mr. William N. Bonner is here, of the Public Works Department of Boston. He is an electrician and perhaps can answer.

Mr. Merrill. My point was that, after you connect up with the waste in the cellar and also the main in the service box and the current is applied, you can feel the pulsation, or the alternations, if you have a mind to call them so, of the current in the pipe. I was wondering if that had any real value in thawing other than the heat that is produced by the current passing through the pipe.

Mr. Wm. N. Bonner. In answer to the gentleman I would state from my experience with both currents that it is hard to determine whether you have the required amount of current, regardless of the sense of touch, by pulsating movement. My experience with direct current is that it is impossible to determine just when the water will come. It does not create any heat in order to enable you to determine. There are times when some men make mistakes by raising their voltage, which naturally decreases the amperage in proportion to the voltage, so as to create enough heat to enable them to determine that the pipe is getting warm. As I said before, you are making a big mistake by doing that.

Mr. J. A. Hoy.* In regard to approximately what it costs to thaw by electricity, I would say that in Worcester we have done approximately 409 services with current furnished by the electric light company of Worcester, at an approximate cost of $3.76 per service. It is a question whether, if you had your own equipment, with the number of amperes that you have to use, you could do it at that cost. We have done approximately 4 200 with just the hot water, where we had a straight run. Of course if there were angles and turns you would require thawing apparatus. But the electric light company furnished about five or six men, and the approximate cost was about $3.76 a service. Now, if you had your own equipment you would require a number of men, and, taking the labor into consideration at the present time, it would probably cost considerably more than that. Of course on the electrical part of it, it takes time to wire it and get all ready, while you would be ready and going ahead with the thawing by the hot-water process, you would have so much more of a start, and if you had a straight line you would perhaps have it done so much quicker than with the electric light company thawing it out.

Mr. Diven. I do not think I could get it done as cheaply as that; I should want the apparatus. There might, however, be frozen services where the city current was not available. We paid during that cold winter $10 per service to the electric light company, plus the cost of the current.

Mr. David A. Heffernan.† We had a private concern do our thawing in Milton, and it cost us just $50 a day. They had three men, including

* Foreman, Water Department, Worcester, Mass.

† Superintendent, Water Works, Milton, Mass.

the chief engineer, and we had to hire one man from the Edison Light Company. And they had one man for inside work. We ran up against bad weather, for instance, and if we had a rainy day, or something like that, the men would not work. The apparatus was put on wheels, horse driven. We were up against it in stormy weather. Now, $50 a day is pretty expensive. Of course the Dedham Water Company was very fortunate in having a second-hand truck, and I think if you can get an outfit like that, get a second-hand truck, a second-hand generator, and the other fixtures that go with it, at an expenditure of $1 000, or something like that, that it is money well spent, and then put the apparatus away, store it for the bad weather. From the present reports of the storms and cold weather they are having in the West, I think Mr. Gifford may have use for his apparatus before long. Suppose we did get cold weather at this time. You don't know whether you will be able to get this machine or not. There are not very many of these machines on the market, and you have to wait your time. We worked during that cold spell, night and day, from December 29, I guess for three weeks, before we got rid of the machine. It cost us over $700. We got nothing in return, nothing to use in the future. Now, if you can get an equipment ready for $1 000 or $1 200, and lay it aside for a case of emergency like that, I think the money is mighty well spent. I congratulate Dedham in being ready for any kind of weather that comes along.

Mr. George McKay, Jr.* I had occasion to look into the matter of thawing out services some time ago, and I ran across a plant they have at Trenton, N. J. They had about 2 000 services frozen in 1917 and 1918, in the freeze-up at that time, and they built a self-contained plant, — it was a generator with a new motor, — fixed it up and put it on a truck, and thawed out their mains with about 225 to 250 amperes and about 10 volts. If anybody is interested in getting further details they can write to Mr. Bugbee, and I am sure he will tell them the plant has worked very efficiently.

Mr. Gifford. I should like to have Mr. McKay tell us what experience he has come across in thawing mains where the joints have been run with Leadite or some similar preparation. I understand he has had some experience.

Mr. McKay. Mr. Bugbee said they had about 2 000 services frozen and I asked him if they had ever thawed out any where the lines were laid with Leadite and he said, yes, and that he never had the least trouble in thawing out the services. Leadite, of course, is a poor conductor of electricity, but you do not depend entirely upon that, and unless you have an insulated gasket you will have a film of water there. Even a film of ice or water will carry sufficient current to thaw out your services. When they have had any trouble in thawing out services it could probably be traced to some other cause. Water itself will carry sufficient current,

* Of the Leadite Company, Philadelphia, Pa.

and the trouble had been they used too high a voltage. If you keep your voltage down to 250 amperes you will thaw out any freeze-up you run across; at least, that was their experience down there with 2 000 services. Boston has also made experiments. I was getting this information at the time, and they discovered it themselves, — that they could thaw out services with leadite joints. They discovered it just about the time I got the information, but I sent it along anyway. I think Mr. Hawley, too, of the Pennsylvania Water Company, has also — I am not sure about this, but I think he is thawing out lines with Leadite joints. He had quite a few miles of it laid.

Mr. Gifford. The testimony which the committee got last year was that mains run with Leadite or similar preparations were impossible to thaw. I understand the City of Boston has been making experiments, using material of that kind for joints, putting a lead wedge in the bottom to carry the current. Perhaps Mr. Bonner could tell us something about the experiments they made in that line.

Mr. McKay. I believe when they started to make their tests they did put a lead wedge in the bottom of the pipe to thaw it out, but they afterwards discovered it was not necessary.

Mr. Bonner. In answer to Mr. Gifford, would say that that is true, that we did decide to make the test by inserting the lead wedge. Of course naturally it was satisfactory, but that lead wedge had to be the equivalent, or, in other words, to be of the same diametrical measurement as the wire. In other words, if you used a 14-gage wire, there is a maximum limit to the carrying capacity of that wire. If you go above the carrying capacity of the wire you melt it. That applies to the lead wedge. For example, if you put a lead wedge in about $\frac{3}{8}$ in. square and then send 350 amperes through it, your wedge is gone. In order to overcome that you would naturally have to build your lead wedge in proportion to the maximum current required for the thawing. There is no limit to that.

However, to make a long story short, it has been decided — and it was very cleverly designed by Mr. McInnes and Mr. Finneran who were determined to make a careful analysis of this so-called Leadite — and after two or three different tests, I have come to the conclusion, and I have been at the electrical business going on fourteen years — that Leadite does not retard the progress of electricity in any way, shape, or manner, as long as it is properly run.

Mr. H. V. Macksey.* I merely wish to say, Mr. Chairman, that I appreciate the value of the work done by Mr. Gifford. Of course he is a pioneer, and like all pioneers he has to work with the material that he has. But there is one great difficulty which a man working in a small city or town meets that he gets rid of. Now, if you are in a large city and you have services frozen by the thousand, it is safe to say that you have blocks and they are frozen right along, and your crew can slip from one house to the

* Superintendent, Public Works, Woburn, Mass.

next, and you do your work very cheaply and very rapidly. One connection with the overhead wires of the service corporation will do a lot of work for you. But if you are out in a sparsely settled district and are fortunate enough not to be frozen up generally but get a bad one here and there, in that case you have long jumps between and a new connection to be made every time, and those things cost money. Not only that, but under certain weather conditions it may be that you will not be able to connect up to the overhead wires, and then you are tied up at a time you ought to be working, and might be working if you had such an apparatus as is contemplated and carried out by Mr. Gifford. So that if we can find some apparatus of our own, which can be moved around well in all kinds of weather and put to work, we will accomplish something, and will have something which the service corporations cannot give us.

Then there is another thing to say. You spoke of being saved the expense of the expert men from the electrical companies. There are very few men who are particularly expert in this kind of a problem. They are just butting into it and feeling their way, the same as we all have to do. And it seems to me that it would be well for the companies, and the cities and towns operating water supplies, to try and build up their own little experts in that particular line, as they have in others; for we have found by experience that it pays better to keep our own men right on the job to do our work than to depend upon contractors on almost any class of work that we do.

EXPERIENCE IN METERING FIRE SERVICES.

FREDERIC E. BECK.*

[*October, 1919.*]

After experimenting for several years in an endeavor to find some method whereby the flow of water through strictly fire-service lines could be controlled and the amount of water used or wasted through such lines obtained, it was decided early in the present year that the only positive method of obtaining this information was to install meters on all fire-service lines connected with our mains.

In making this decision to install meters on all fire-service connections, of which we have 230, we were governed by the fact that we had positive knowledge that large amounts of water were being either used or wasted through these lines. This information was obtained from time to time by means of the Pitometer survey which we were making, in order to reduce our underground leakage, together with the visible evidence of seeing roofs wet down during the hot summer days, several fire streams being played simultaneously on huge coal piles for days at a time, and such other like usage of water which *might* be taken from our mains without our knowledge and without payment for the water used.

On investigating cases of this kind, we usually found that the water being used was supplied by pumps on the secondary source of supply, which in our city is a near-by canal, and was not taken from our mains. In several cases, however, the flow was entirely from our mains, and taken through fire-service connections.

In order to lighten the financial burden of metering 230 services, it was decided to first meter those plants having outside yard systems, where the chance of underground leakage was greatest, and to proceed with the metering of the balance of the services at a rate that would insure the complete metering of all services within a period of four years.

During the past season fifty fire-service meters have been installed, and the results obtained certainly warrant us in the completion of our program.

All meters are located as near the street line as possible, and are placed in brick or concrete pits; and all expense and cost of setting, including cost of meter, is borne by the company, a nominal service charge being made for each service, in addition to requiring payment for all water passing through the meters, excepting that used for the extinguishment of fires or the testing of the equipment. In case of fire or testing of equipment, the consumer is required to give notice on cards furnished for the purpose, which show the time and duration of the fire. The allowance

* Chief Engineer, Consolidated Water Company of Utica, N. Y.

for water used for these two purposes is then based on the normal flow of water through the meters, as shown by previous meter readings.

The annual service charge for fire-service connections is $40 for 4-in., $50 for 6-in., and $75 for 8-in. connections. In defense of this low service charge it is necessary to state that all fire-service connections are made at the expense of the consumer from the main to the property line. I am not, however, defending this method of installing services at the expense of the consumer, but simply our low service charge.

The cost of installing the meters on service lines already in use has averaged $153 for 8-in. meters and $135 for 6-in. meters, with a range of from $80 to $239 on the 8-in. size and from $75 to $182 on the 6-in. meters; these prices do not, however, include pavement replacement, but include all other labor and material costs for placing meter and constructing meter pit.

On the fifty meters installed, all but three show a constant flow of water, the three exceptions being new connections to buildings having no yard system and but small sprinkler systems.

The rate of flow through the fire-service connections varies from 6 to 3 000 cu. ft. per day.

But little opposition has been encountered from the owners or managers of the plants metered, and where the flow of water could not be traced to unknown connections with the fire-service pipes, they have been extremely anxious to locate and repair any leaks which might cause a loss of water.

In view of the results obtained on the fifty services metered, I would advocate the placing of properly designed meters on all fire-service connections, and especially those having extensive systems of piping with yard hydrants attached.

Discussion.

Mr. Frank L. Fuller.* Please tell us what kind of meters were used.

Mr. Beck. We use, in Utica, the Neptune Protectus; not that that is the only meter for that service, but we are standardized on that meter.

Mr. J. M. Diven.† Have you had any trouble with the Underwriters' Association in the installation of meters?

Mr. Beck. Not the underwriters. The Mutual Insurance companies have made us several visits on that subject. They do not approve the metering of fire-service lines. It is because it is one more attachment on the main that they would rather not have there.

Mr. Diven. We put meters on fire services without consulting the underwriters, and had a very sharp letter from the Underwriters' Association at Syracuse saying we were installing these meters contrary to their

* Civil Engineer, Boston, Mass.

† Superintendent, Water Works, Troy, N. Y.

rules and regulations. My reply was that we were making the rules and regulations for supplying water, and were running the works under our regulations and not under theirs. They said there was no stealing of water.

At the first mill examined, we found a $1\frac{1}{2}$-in. connection. This mill claimed they were using only a fire service, for which they paid a nominal sum of $20 a year, for a 6-in. connection. We found this $1\frac{1}{2}$-in. connection running to an old-fashioned water closet, under full head, and traced it to the fire service. Finally we shut the fire service off to convince them that that was where the water came from. "Well," they said, "there might be one case."

The next factory was almost directly across the street. Before going in we shut the water off to see if they said anything. We had hardly got through the door before the engineer came in great distress, saying we had shut the water off, while he was filling his boiler. We told him we were not shutting the water off from his boilers, but shutting off the fire line to test it.

After a little while we got on the street car to go to the next mill, but they did not leave the car; they had seen enough.

You spoke of using the by-pass in closing down the line. I have had another run-in with the insurance authorities on that, they claiming I had no right to shut that down, as a fire might occur during the test.

Mr. Beck. That is why I do not consider the test satisfactory. You can't shut it down for twenty-four hours, which is the desirable length of test.

Another thing I did not mention was the charge for water. We make no charge for water used for fire prevention or testing. We are sending a card out to the factories with the request that they fill it in in case of use of water for fire prevention or testing, and return it to us.

Mr. George H. Abbott.* Do they usually send the card back to you?

Mr. Beck. It is a part of our system which is not yet in working order. We are just getting those cards out.

Mr. Abbott. It has been our experience that they pay no attention to those things at all, and then the manufacturer wants a reduction in his bill for water used for testing.

Mr. Beck. We undoubtedly will get that later, but we have not been up against it yet.

We have had a conference with one representative of the insurance company, and with a mill owner, relative to illegal taking of water from the fire-service pipes. The mill owner claimed that if we found a mill taking water it should be metered and made to pay for it, but the honest should not be made to suffer for the acts of the dishonest. We had just installed meters the day before on his plant. At five o'clock I sent a

* Treasurer, Water Company, Southbridge, Mass.

man out to read the four meters, and there was a registration through the four meters which amounted to $96 a quarter at our rates. We met in the evening and he repeated that if water was being taken by any mill it should be metered and the owners made to pay for it. After getting that fact firmly established I showed him the readings of their four meters, indicating that they were not among the innocent, and the meeting adjourned.

MR. ABBOTT. You would have to install a meter to find out whether they were honest or not.

MR. BECK. Yes.

MR. ABBOTT. Do you pay for the meters?

MR. BECK. Yes. And before this meter service we had a charge for fire protection of 37 cents a thousand valuation of building and contents. But then there was a rule made that gave a discount of 20 per cent. for each hundred dollars' worth of water used for domestic purposes. As all of the large mills use over five hundred dollars' worth a year, they had their protection free. They objected somewhat to this additional charge of $50 to $75, but not seriously. After metering one plant, talking with owners of another, and showing the record of the first metering, there was no arguing on their side.

MR. ROBERT E. HORTON.* It seems to me that the subject of metering fire services is one of tremendous importance. Something was said this morning about the ratio of night and day consumption. Every one of you that has had anything to do with the matter of water-waste prevention has probably run across instances of unexplainably large night consumption. I believe one ratio was given which was about 80 per cent. I ran across a ratio of 20 per cent. in night consumption between two and three o'clock in the morning as compared with the average of twenty-four hours. I was called into a small town to find out why it was they were short of water and very quickly found that they were not uniformly short but only some of the time, and they left me free to do what I wanted to. We said in a vague way we were going to make night tests. We found that there were two prominent factories in that small town, and one of them used water very extensively at night. The other used it twenty-four hours a day. One of those factories had a well and some one said, " If you go down to Jones's mill and see that well, you will realize that the thing for you to do is to build a well somewhere in that location and get all the water you want; they have an inexhaustible well there that yields 100 000 gal. a day, because they use that much in the mill." I went to see the well. They had a fire-service main, a 4- or 6-in. line running into the mill. They were not taking any village water; according to report, had no connection with the main for taking water. But, for some reason they were unable to explain, they had a block of concrete some 8 ft. wide, and probably about 3 ft. thick, extending from the curb

* Hydraulic Engineer, Albany, N. Y.

in front back into the mill. The pump used to pump the water from this well was located at the rear end of that block of concrete. The reason for extending it out to the curb was not given. I was very much pleased with the situation as I saw it. They were undoubtedly pumping 100 000 gal. or more of water a day.

Another rather surprising thing about it was that the pump was not consuming any power. You could connect it up, but there was no back lash. Apparently, if the shafting had been disconnected, the pump would have run just the same. I could not explain that, and thought also that the water was of a very remarkable character. I wanted it analyzed and was very enthusiastic for the city to get another well like that if they could. They allowed me to take a sample or two. Now, the village water supply was taken from a village several miles away, and was very soft water; the water from the place where this mill was located was invariably of a different character. Strangely enough, this well analyzed almost identically with the analysis of the village water.

Now, if the fire-service meter had been put in on that line when the fire-service line was first put in, the village would not have been short of water, and one engineer's fees less would have been the result.

Mr. Dow R. Gwinn.* Several years ago we had a rate case before the Public Service Commission of Indiana, and, in the order, it was required that all private fire lines should be metered, with a minimum rate for fire-line services, 50 per cent. greater than the minimum rate where fire service was not used. We then started in to set the meters on the fire lines. In one case where they were supposed to pump their own water to the factory the inspector reported that he found the hose connected with the fire hydrant running into the factory. I asked him if there was any water going through. He said he couldn't tell, only it was inflated as large as it could be. We then put the meter on. This concern had a 6-in. line to supply 3 fire hydrants for fire protection only. They were paying us $10 a month for fire service, and seemed to take it for granted that they were donating that much money to the water company. Their bill last month was $255; the month before I think it was $247; the month before that it was $184, but they do not say a word. They pay these large amounts with less comment than they used to pay $10 a month.

By the way, I should say that on these 6-in. lines we have set 4-in. meters. We do not see any sense in puttin a 6-in. meter on, because they do not need it. If they had a stream from each fire hydrant, getting 250 gal. a minute from each one, they would not exceed the capacity of the 4-in. fire protection meter. The minimum rate on a meter of that size is $22.50 a month. They are allowed $22.50 worth of water for that amount. So that fire protection need not cost them anything. The company furnishes the service pipe up to the curb and sets the meter; furnishes it all free of charge. We have one 8-in. fire-protection meter,

* Manager, Water Company, Terre Haute, Ind.

and the minimum monthly rate on that is $150. They do not object to it at all. They are supposed to pump their own water, and they do pump some water, but this concern had a bill in December of about $650.

Mr. Diven. They must be using city water for power to pump with.

Mr. Paul Lanham.* I have had experience in testing a large number of meters with Pitot tubes. A large number of those have been fire-service meters. In practically all cases, I might say, the fire-service meters are not meters at all. That is, as long as the stream of water going through the fire service is small, the meter is accurate; but as soon as the stream becomes large enough to open the check-valve, in the commonly used type of fire meter, the meter is *nil*. In a great many cases the slippage is 100 per cent.

I should like to ask Mr. Beck if he has any reason to believe that the Trident meter is free from that defect.

Mr. Beck. The only test we have made on a 2-in. connection was on a meter by-pass. It registered 98 per cent. on a 2-in. stream.

Mr. Lanham. Well, I can say that on new meters I have tested and seen tested the accuracy has been all right on the type of meters I was referring to. But the trouble is that the meter which is called upon to measure the fire-service flow remains idle most of the time, may for years, and then, due to increased underground leakage or the beginning of illegitimate use through the fire line, that meter is called upon to operate and fails. If you are dependent on meters of that sort you are practically without meters on the fire line after a few years.

Mr. Diven. Do those tests include both the detector meters and compound meters?

Mr. Lanham. I would be inclined to say that my experience has been wholly with the detector meter.

I do not know where to draw the line between compound and detector meters. The Hersey Company, for instance, has two types of meters. It has a purely detector meter, which makes no effort to measure the flow, and then there is the type F.M.

Mr. Diven. I refer to the two general types, — detector and compound.

Mr. Lanham. Well, it covers both of those.

Mr. Beck. Unless we have a great change we will not be up against the large meter, not being called upon to operate, because they are all operated several times a year.

Mr. Lanham. Is that on account of fire tests, or something of that sort?

Mr. Beck. Use of the main. Leakage, I do not think, would amount to much. Practically every meter is consuming water, even the fire-service meter.

* Engineer in charge Waste Prevention, Washington, D. C.

Mr. Lincoln van Gilder.* I think one of the most important features of the fire-service meter is the fact that even though the fire service were not registered it would not be a very serious loss, for the reason it is used a very few times in the lifetime of the meter. Most cities would not think it a very serious matter, for they do not get any revenue from pipe used exclusively for fire.

Mr. Charles W. Sherman.† I am informed a great many cities and towns make no charge for water used for fire service. And the water that is used for fire purposes would be deducted even if measured in making charge for the service. I think that is an entirely appropriate and proper practice. So that there would be no such condition, even though the fire-service meter failed to register all the fire flows, if the small meter registered all the other flows. I judge that did not prove to be the case with Mr. Beck.

Mr. W. C. Hawley.‡ What Mr. Sherman says is undoubtedly true in a great majority of the cases. But we get what is equivalent to a fire flow when there is no fire. We are getting it time and time again. I cannot give any explanation or any reason why. Unfortunately, the additional meter does not seem to gage that flow. We know that the check-valve is open because the telltale meter indicates it.

There was another case where, for years, we tried shutting the valves and testing with a by-pass meter. There was always more or less leakage, and we were unable to get any reasonable response from the management in the way of making repairs. We began testing regularly and rendering bills on the basis of the average of the tests, and when they found they had bills to pay they got busy and most of the leakage stopped, but still there was water going through. In the case of some of our tests we discovered they were taking large quantities, and then I put the detector meter on and found they were taking for various purposes which they considered perfectly legitimate. They are now paying for that. In that case the rates of flow were not sufficient to open the check-valve.

Mr. Horton's experience reminds me of an incident which occurred about ten years ago. We were furnishing water to an amusement park. They had two lines; the fire line was not metered and supplied several fire hydrants only. I was a little suspicious and had the place watched for some time. There was a hose attached to one of the hydrants, and sometimes there were indications of water at the end of that hose. I went up to the park one evening, with my wife and little boy. The boy discovered the miniature railroad and we had to take ride on the cars. While we were sitting on the cars a policeman stepped up to the engineer of the locomotive and said: "Well, you certainly filled her up last night," referring to the pond for the "shoot the chutes." "Have you got orders?" "Yes, to fill her up whenever I please." I went home and got my men

* Superintendent Water Works, Atlantic City, N. J.

† Of Metcalf & Eddy, Boston, Mass.

‡ Chief Engineer and General Superintendent, Pennsylvania Water Company.

and we stayed there that night and watched them take water from the fire hydrant. We shut the water off the next morning, and before we got through got something over $500 in settlement. It was rather an unusual way to get the information.

Mr. Beck. I think, in the connection you speak of, with a large and a constant flow, I would not treat that as a fire-service line. I would treat it just the same as any other line, and meter accordingly.

Mr. Harry A. Burnham.* The metering of fire-service connections has been a perplexing question for several years. It is a generally accepted fact that for the scientific operation of a water-distributing system, metering is proper and usually necessary for all connections through which water passes for domestic or industrial purposes. Connections in this class are mostly small in size and large in number.

In the case of fire-service connections which are large in size and comparatively few in number, the need of metering is not so apparent because, with the standard fire-protection equipment of sprinklers and hydrants supplied through a connection independent of the industrial pipe system, no flow is expected excepting in case of fire. With a well-maintained fire system and normal conditions, no flow need occur from year to year excepting for prearranged inspector's tests and normal leakage.

Much ingenuity has been shown in recent years in the design of meters to obtain the unobstructed waterway necessary for large fire flows, and there are doubtless places where these meters are necessary.

The matter of conservation of water supplies is always with us, and is of the utmost importance. The Mutual Insurance companies desire to assist the water-works engineers in every possible way to properly control the use of water from fire systems in the manner best suited to conditions as found.

I might add, in connection with the story Mr. Hawley just told, a little experience I ran across in a large city, not long ago, where the water company continued to present very large water bills rendered from a detector meter, and the concern paid them under protest for two or three months, and finally, after they had exhausted all other resources of finding where the water was going, they took the meter apart and found a block of wood caught in such a way as to deflect a large part of the flow that should have gone to the straight line through the meter. The outcome of the whole thing was that the company that had that meter on its premises got a lot of money back.

Mr. Diven. Can you tell us the size of that block of wood?

Mr. Burnham. It must have been 3 by 4 in., or perhaps 5 by 6 in. in size, such as commonly comes in pipes.

President Killam. I might say that in 1907 a general act was passed by the legislature of Massachusetts for the Metropolitan Water District, which included everything but fire lines. In a section of the

* Engineer for Factory Mutual Fire Insurance Company.

city were two fire lines for high service. They had given us considerable trouble, and for years we had not been able to know just what was taking place. The city authorities claimed that it was all used for fire purposes; that they had inspected the premises and could not find anything else. I was not entirely satisfied, and recommended putting in cocks each side of the main valve, for testing at least twice a year. Several tests showed what you might expect on a line of that length with leakage. Of course, when we made these tests we had to notify the city authorities, so that in case of fire they would be protected and we could open the valve readily. We had a man stationed there all the time. At last I decided to notify just the fire department, and run a test ourselves. We got a very large flow on one of the mains. I called the attention of the city authorities to it and they investigated it and said they could not find anything. That went on for about a year, and finally I recommended putting on a detector meter of some kind. The city authorities were requested to install this detector meter. They did not refuse but they did not comply. That went on for about six months, and then our commissioners notified them that if it was not installed in sixty days the line would be closed permanently. They made preparation at once to install that meter. The meter was installed in May, and the average since that time has been 30 000 gal. a day from that metered service. It is being used by some of the factories along the line that are supposed to have only fire services in their buildings.

Mr. Burnham. I was hoping, during this discussion, something might be said about first-hand experience in sealing hydrants and sealing sprinkler drains, and such things as that, which I am quite sure the water-works superintendents have had something to do with, in order to properly control the taking of water from the water systems.

Mr. H. T. Gidley.* In our town a 6-in. main furnished fire service to a large factory, and there was no evidence of their having taken any water from this fire line, except for their boilers which metered all right. Still, when we installed the detector meter we found they were using water from the fire line at the rate of 45 000 cu. ft. a month. They must have taken it from the service way inside, where we could not detect it until the meter was put on.

Mr. William F. Sullivan.† The only case I know about of the sealing of fire services, except in the larger factories, is rather unsatisfactory. The smaller factories, where there is not that close supervision, the minor officials, the master mechanic or some one else, have a habit of breaking the seal and requiring the water department to re-seal and go to the expense of an inspection. Of course, I speak now of a place where there is no charge for fire service.

Mr. A. E. Martin.‡ In Springfield we have adopted the plan of metering all fire services, — all new ones, especially, — and our old ones

* Superintendent Water Works, Fairhaven, Mass.

† Superintendent Pennichuck Water Company, Nashua, N. H.

‡ Superintendent Water Works, Springfield, Mass.

as fast as they can be worked up. If I understand Mr. Beck right, they are installing the detector meters free of expense to the consumer. Is that so?

Mr. Beck. That is right.

Mr. Martin. I think there is a decision by the Massachusetts Supreme Court that it is not only right and proper that those services should be metered but that it is right and proper that the owner should pay for the meter as well as the installation of it. We have adopted the policy and are requiring the owners to pay for the meters.

I am going to say that in requiring payment for water, we attempt to divide the water used for extinguishing a fire, — we do not charge for that amount of water, but for all other water, for whatever purpose used, we collect. I think that Mr. Abbott (from Southbridge) says that they do not charge in that town for the water used for inspection purposes. We distinguish between those, and just simply say, for all water used for extinguishing a fire.

Mr. Sullivan. I would say that our rule is similar to Mr. Martin's. That was a Supreme Court case in Lowell, wasn't it?

Mr. Martin. Yes.

Mr. Sullivan. We do not charge for extinguishing the fire, but on all new fire services charge for the meter. but nothing for inspection.

Mr. Van Gilder. We charge, in Atlantic City, the cost of installing the service from the main to the curb, but furnish, set, and maintain the meter free of charge. We charge for all the water the meter registers unless it can be shown that the water was used for fire prevention. If that is the case we make a proper rebate. There has been no difficulty in arriving at that.

Mr. George H. Abbott. I would say that in our town we tell the owner to put on a fire-service meter and charge him for the water that is used, but not for what is used for fire. When the meters were first installed we gave the owner the first quarter to stop leaks at his factory and do as much as possible to eliminate the waste before sending the first bill.

Mr. Edward D. Eldredge.* I should like to ask the speaker, in reference to the meters he spoke of, — where he locates them, whether on the land or in the street.

Mr. Beck. We endeavor to locate every meter at the curb line if possible, but in some cases we can't do that, and in one or two cases we have put them in the basement of the mill or building.

Mr. Eldredge. Is there any trouble with freezing?

Mr. Beck. We have had no trouble yet. We only started this spring installing them, but have had other meters and had no trouble with them.

Mr. C. W. Sherman. Are they located under the sidewalk?

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* Superintendent Water Works, Onset, Mass.

Mr. Beck. Partly under the sidewalk, and between the curb and the sidewalk, in the park spaces.

Mr. Sherman. Mostly between the curb and the sidewalk?

Mr. Beck. Yes.

Mr. Martin. In regard to freezing. It is a very simple matter to protect one of those large meters from freezing by putting in a false cover on the inside. We build a little ledge around in the brick above the meter, just high enough so that the dial of the meter will come up through that, and that is permanent and stays there unless we have some repairs to make. Put in a double floor, as you might call it, just above the meter. That makes an air space around the meter. We have never had a detector meter freeze.

Mr. Killam. How long do those boards last?

Mr. Martin. It depends somewhat on the location. Our ground is very dry at Springfield; the soil is sandy, and we have not had one rot-out yet.

Mr. Killam. I know, in some sections, two or three years is as long as they will last.

I should like to ask one question of Mr. Beck: Do you install these detector meters on the main line or on by-passes?

Mr. Beck. On the main line.

PROCEEDINGS.

March Meeting.

Hotel Brunswick,
Boston, March 10, 1920.

Vice-President Brush in the chair.

The Secretary read applications for membership, approved, from: Marcel Pequegnat, Kitchener, Ont., superintendent of water commission; George E. Watters, New London, Conn., assistant engineer, water and sewer department; Leonard J. Hathaway, Jr., New Bedford, Mass., principal assistant to city engineer; Edwin H. Rogers, West Newton, Mass., city engineer; George C. Gensheimer, Erie, Pa., commissioner of water works, who were duly elected.

Mr. John C. Chase, for the committee appointed at the February meeting, presented the memoir of Frank L. Fuller.

Mr. X. H. Goodnough, for the committee appointed at the February meeting, presented the memoir of Frederic P. Stearns.

The Chairman. I believe that there are two charter members of this Association that are now honorary members and that these two charter members are with us to-day, — Messrs. Coggeshall and Hall. I will ask these gentlemen to stand, so that we can see what charter members look like.

[Messrs. R. C. P. Coggeshall and Frank E. Hall stand, amid great applause.]

The Chairman. I am going to ask Mr. Sherman, as chairman of our committee on Standard Specifications for Water Meters, to give you an outline of the progress that has been made to date.

Mr. Charles W. Sherman. *Mr. President and Gentlemen,* — I presume that many of you have thought the Committee on Meter Specifications was more or less of a joke. It has been in existence for four or five years, and up to the present time, has not produced anything to warrant its existence. I must confess that for a considerable part of the time I wondered myself whether it was a joke. I am now beginning to have not only hopes, but very considerable confidence that it is not by any means a joke.

Largely through the efforts of our fellow-member, Mr. Tilden, who became chairman of a Committee on Specifications of the Meter Manufacturers' Exchange, the manufacturers have gotten together and have discussed, and to a considerable extent standardized on paper, many of the most important points which a standard specification should cover, and on the basis of their conferences have gotten up specifications which they have submitted to our committee.

About the time that was being done, the American Association, wishing to forestall the possibility of having two competing specifications, also appointed a committee on meter specifications, with the idea of the two committees working jointly, or at least in parallel, so that their labors might be coördinated into one specification. It seemed that that might best be accomplished by those two committees sitting jointly, practically as one committee. We have been so sitting for, I was going to say, twenty-four hours steadily previous to this meeting. We met yesterday afternoon and sat until very late in the evening, and again this morning from nine o'clock until the time of the Executive Committee meeting, and with the aid of the material which the Manufacturers' Exchange has put before us, and with what our members already had, have made such progress that we think it is going to be possible to draft a specification, discuss it with the manufacturers, and agree upon it in time to publish it in the June journals of the two associations, so that the American Association may take it up for discussion at its convention in June in Montreal, and this Association at its convention in September.

The specification, I should say, applies only to disk meters. We shall not attempt in our first report to cover anything more than that. In view of the very large percentage of disk meters compared to the total number of meters sold, we believe that we shall have made very considerable progress if we succeed in getting a specification for disk meters. Later we hope to come along with specifications for other types, but at first we will give you enough to consider in the one specification.

Mr. Reeves J. Newsom, commissioner of water supply, Lynn, Mass., read a paper on "Progress in Making an Established Water Works Modern and Efficient." Messrs. Caleb M. Saville, R. C. P. Coggeshall, Lincoln Van Gilder, and Charles W. Sherman participated in the discussion.

A paper on "Atlantic City High-Pressure Fire System" was read by Mr. Lincoln Van Gilder, engineer and superintendent, Water Department, Atlantic City, N. J. The discussion was participated in by Messrs. Caleb M. Saville, Richard D. Chase, and Vice-President Brush.

Mr. Fred O. Stevens, superintendent, water works, Weymouth, Mass., opened a discussion on "The Efficiency of Pipe-Jointing Compound as Compared with Lead."

The Secretary read a communication from Mr. E. E. Wall, water commissioner, St. Louis, Mo., on this subject.

Messrs. R. C. P. Coggeshall, Stephen H. Taylor, Lincoln Van Gilder, Frank A. McInnes, John Doyle, Frank J. Gifford, George McKay, Jr., A. E. Martin, Vice-President Brush, and Robert S. Weston took part in the discussion.

The Chairman. At the meeting of the Executive Committee this morning it was voted to hold our annual convention this fall at Holyoke.

Adjourned.

FRANK LOUIS FULLER.

Frank Louis Fuller, the son of Hezekiah and Emeline (Jackson) Fuller, was born July 11, 1848, in that part of Needham which is now Wellesley and died at his home in Wellesley Hills, January 30, 1920. His death was very sudden and evidently from a heart trouble, for he had been in good health until a few minutes before his decease.

He graduated at the Mass. Institute of Technology in 1871, and immediately took up the profession of civil engineer, in which he was in active practice until the day of his death. While he had an office in Boston his activities extended throughout the state and into New Hampshire and Vermont as well.

Among his most important work was the original development or additions to the water-supply systems of Acton, Arlington, Marblehead, Methuen, Monson, Shirley, Waltham, Ware, Webster, West Brookfield, Winchendon, and Uxbridge, Mass.; Franklin, N. H., and Brattleboro, Northfield, and Woodstock, Vt.

He became a member of this Association on June 18, 1886, and was a very regular attendant at its meetings, participating freely in discussing the papers presented, which added materially to the information brought forth. He had also contributed several papers of interest.

He was a member of the American and Boston societies of civil engineers, the American Water Works Association, the American Public Health Association, and the Wellesley, the Congregational, and the Appalachian Mountain clubs. He was a member of the Wellesley Hills Congregational Church and had served as one of the deacons for many years. He was also a member of the Wellesley Water Board from 1887, being chairman of the board the greater portion of the time.

In 1881 he married Miss Julia L. Morrill, of Boston, who survives him. Mr. Fuller was an exceedingly genial and courteous gentleman and in his death the Association has lost a valuable member, who will be greatly missed, particularly by those with whom he has been intimately associated for a third of a century.

Francis C. Hersey, Jr.
John C. Chase.
George E. Winslow.

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New England Water Works Association

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

PROGRESS IN MAKING AN ESTABLISHED WATER-WORKS SYSTEM MODERN AND EFFICIENT.

REEVES J. NEWSOM.*

[*March 10, 1920.*]

This paper is a brief account of how the Lynn Water Works has been enabled in the last four years to meet increases in wages of about one hundred per cent. and in the costs of materials of over seventy-five per cent., without any increase in the amount of water sold and without an increase in rates.

In July, 1916, when the writer took charge of the water-supply system of Lynn, he found it in the condition which is so common with works that have been controlled by laymen, well meaning and sincere in their efforts but without technical training or education. The real work to be done was not merely the operating of the plant but the application of engineering principles to the methods of operation, and, as is the case with almost any works that has been so controlled, the field for improvement was indeed a lucrative one. The improvements recorded below cover, as will be noted, practically every division of the system, and are given not in the order of their importance but rather in the order in which they were made.

The Lynn system is supplied by the watersheds of four artificial ponds and the Saugus and Ipswich rivers. The combined catchment area from which water is drawn covers fifty-eight square miles, and the available yield is about 35 000 000 gal. per day, while the present consumption of the city is approximately 8 500 000 gal. per day. There are three pumping stations on the supply system, used to pump water from the rivers, or from one pond to another as it passes through them in the process of purification. A fourth pumping station, located in the city, pumps into the mains and the equalizing reservoir and standpipe. Three of the four ponds are in a chain, with a combined storage capacity of a little under four billion gallons, and it requires from four to eight months

*Commissioner of Water Supply, Lynn, Mass.

for water to pass from the rivers into the distribution mains. The fourth pond, with a capacity of 350 000 000 gal., is used as an emergency supply to the distribution mains, and it can be filled from two of the other ponds.

The distribution system is about 58 per cent. metered, and the per-capita consumption is slightly over 70 gal. The system is valued at about $5 000 000, with a net bonded indebtedness of approximately $1 000 000. The receipts from the sale of water have varied little from $350 000 per year since 1916, of which from $130 000 to $165 000 yearly has been needed for debt requirements.

One of the first things coming to the writer's notice was the fact that the abatements, including adjustments for advance fixture assessments, amounted to about $13 000 per year. A complete reorganization of what proved to be very lax office methods, together with a strict enforcement of the regulations and the shut-off rule, has saved us $7 000 per year of this amount.

The service pipe in use by the department in 1916 was of a type manufactured with a lining of high first cost, and when used with Lynn water it did not stand up satisfactorily. After some investigation it was decided that the economical and most serviceable pipe we could use, requiring as we do in excess of 25 000 ft. per year, was cement-lined pipe. The use of cement-lined pipe is subject to two general difficulties, — the obtaining of a continuous lining and the obtaining of a concentric lining. Ordinary methods applied to cutting cement-lined pipe are not satisfactory, as a pipe cutter by its prying action breaks the brittle lining for about a quarter of an inch, exposing the iron to the action of the water. Fittings which are purchased already lined as a rule leave more threads unlined than can be made up, and if the lining is of cement it is apt to be crushed if it is possible to make up all the threads. This first obstacle was removed by cutting all pipe in the shop to fit the requirements by the use of a metal-cutting machine, which, on a test, cut with a single blade 140 $\frac{1}{8}$-in. disks from a piece of 1-in. lined pipe without breaking the cement. The other problem was solved by the use of malleable-iron countersunk fittings, which we line ourselves with lead, leaving only six threads unlined. When this lining comes in contact with the cement lining of the pipe it makes a snug fit without danger of crushing the latter.

A non-concentric lining was found to be caused by the stoppage of the cones by the wings catching on irregularities in the pipe and the fact that the weight of the follower, which has no centering wings, caused it to displace some of the cement on the lower side of the pipe. The first of these difficulties was overcome by obtaining plugged and reamed pipe, either black or galvanized on the outside only, and the use of spring centering wings instead of solid ones. The effect of the weight of the follower was counteracted by making it slightly larger than the winged cone, and the resistance of the cement which it displaced centered it in the hole already made by the leading cone. The saving effected by the use of this kind of service pipe is in excess of $4 000 per year.

The department in 1916 depended on the use of horses in all its repair work. The motorizing of this work has reduced the number of foremen from 5 to 4, and the number of men on routine repair work about 20 per cent.

The meter repair shop was not equipped to properly test meters of over one inch in size, and no attempt was made to test and repair meters over two inches, although 25 per cent. of the revenue from metered water was registered by these large meters. A newly equipped testing plant has been built, including a calibrated tank of 125 cu. ft. capacity, and when the city has been entirely covered and all large meters repaired indications are that revenue in excess of $5 000 per year will be added.

The Glen Lewis pumping station, which lifts water from Walden Pond to Breed's Pond, was equipped with a motor-driven centrifugal pump when it was built in 1912, but it had no meter for measuring the water pumped, and no tests had been made to ascertain the efficiency of the pumping unit. Using a Lanham Manograph, the water pumped was measured, and after calibrating all pressure and electrical instruments a complete set of test data was obtained covering the performance of this pumping unit. It was discovered that the practice of buying what a pump salesman had recommended had given the city an outfit which was running at an average over-all efficiency of 42 per cent., requiring 90 k.w. to pump 14.3 million gallons per day against a 20-ft. head. At a cost of $10 000 this unit has been replaced by a modern centrifugal unit in accordance with the writer's specifications, which delivers 16.4 millions against a 20-ft. head and requires but 60 k.w. to drive it, operating at 72 per cent. over-all efficiency. The saving in operation by this substitution is $3 300 per year, which is 33 per cent. of the investment.

The Walden Pond pumping station, which pumped water from Hawkes Pond to Walden Pond, was built in 1902 and was in operation in 1916, but has now been abandoned. This was a steam station requiring the usual two men per shift to operate it. The water flowed to the suction well of the pump through an open canal about three quarters of a mile in length, losing about 20 ft. of head in this operation. The water was then pumped through a 30-in. pipe about one third of a mile in length against a total head of 45 ft. Two men on each shift were required to keep the screens clean in the screen house at the end of the canal leading to the suction well, and to operate the gates controlling the supply of water to the canal, making in all 12 men in twenty-four hours for the running of the station.

The writer has designed a new station to do this work, which is so situated that the total length of 36-in. discharge pipe is 540 ft. and the suction is direct from Hawkes Pond. This station is equipped with a motor-driven centrifugal unit, pumping 20 000 000 gal. per day against a 23-ft. head with an over-all efficiency of 74 per cent. This unit is so protected by safety devices that the only attendance required is that

given by the regular patrolman on the pond. This change has effected a reduction in labor from 12 men per day to none, a reduction in head pumped against from 45 ft. to 23 ft., a reduction in the cost of pumping from $5.45 to $1.75 per million gallons, and nets a yearly saving of $9 600 in the cost of operation, and required a net investment of but $35 000.

In 1883, when the city of Lynn was given by the legislature rights to the water of the Saugus River, it was compelled by the same act to furnish water to the inhabitants of the town of Saugus at an equitable rate, which rate, in case of difference, was to be set by a supreme court commission. Under this act the city of Lynn extended its system into the town of Saugus, and until June of last year it dealt with the individuals of the town. The contract between the city and the town which was in force when the writer took charge of the Lynn system provided that the city should furnish water, make inspections and read meters, send bills and collect water charges from the inhabitants of the town, while the town was to maintain its mains, services, and meters, for which it was to be refunded 50 per cent. of the receipts.

The writer's suspicions as to the method used in drawing this contract were aroused by the even figure of a fifty-fifty split, and it was at once apparent that, inasmuch as the city of Lynn stood all the wastage in the Saugus pipes, it would be much better from the town's viewpoint to allow water to waste rather than to properly maintain its services and mains.

The solution, to meter the town's supply and sell it water at wholesale, was not difficult to arrive at, but the proper sizing of the meters and the matter of what constituted an equitable rate where the town's water supply resources had been given to the city were questions not so easily solved. It was necessary to meter both ends of the town, and nothing was known about the amount of the consumption, the proportion required at each end, the size of the maximum and minimum peaks, or the load factor. To ascertain these facts a Lanham Manograph was used on the mains entering the town, and the results obtained were very close, for later, when the meters were put in operation, the pressure drop was but one-half pound. The writer's opinion regarding what constituted an equitable rate was that the town would not be justified in asking for anything less than cost of delivering water to the town line, and studies were begun to ascertain what this cost might be. The records of the works were very incomplete, plans of many structures missing, and the methods of computing costs very diverse and unreliable, so that a valuation study of the supply system was necessary to compute the proper charges for interest, depreciation, extensions, and the maintenance and operation, which made up the cost. This has been done, and for eight months water has been sold to the town under the new plan, and the rate charged is the very low one of 5.1 cents per 100 cu. ft. At this rate and in addition to having given up all the work required under the old contract, the city will receive

over $4 000 more from this business than for the last year under the former arrangement.

The main pumping station was the one bright spot in the system. Its equipment and methods were fairly modern and its records complete, and it was the last place one would look for losses. But only recently a checking up of the difference in levels between the center of the pump and the pond from which the water is pumped revealed a loss on the suction side of the pump in excess of 15 ft. over what is reasonable for the length and diameter of the suction line. This friction, when isolated and eliminated, will mean a saving in operating costs in this station of over $6 000 per year.

These improvements have made savings and added revenue in excess of what would have been obtained by a 12 per cent. increase in rates, and, as stated at the beginning, has enabled us to meet the necessary advances until now it seems that the peak in increased costs has been reached, and that the time has come when relief is in sight by an increase in gross business, some indications of which have shown themselves in the last two or three months.

These improvements have been of the kind to stop wastage and increase revenue, and the other type, those which better service, have had to wait. There are many things along these lines that are badly needed, and are under consideration at the present time.

The small pond which is used as an emergency supply to the distribution system has a very poor watershed from a sanitary viewpoint, and its use would not be necessary had the last pond in the chain of three, which is the ordinary path of the water entering the mains, been provided with two separate pipe lines connecting with the pumping station. The remedy is to abandon the small pond for water-supply purposes, and to do so will require the laying of a 48-in. line through an earthern dam while the latter is in use.

The equalizing reservoir, built in 1871, affords but little more than one day's supply in case of serious trouble in the pumping station, and the standpipe furnishing the higher districts of the city contains but a few hours' reserve against the same contingency. The only feasible solution to this problem is the constructing of a larger reservoir on a hill a mile and a quarter further from the center of the city, which reservoir would be a hundred feet higher than the present one and would necessitate complete new equipment in the main pumping station. Pitot tube tests, to determine the distribution of the load between the four feeder lines to the city, have shown one to be seriously overloaded and its replacement necessary.

The high price and very poor quality of coal now obtainable has caused such a serious drop in station duty that we are figuring on the advisability of burning oil under our boilers. This matter is further complicated by the fact that we need additional boiler capacity at the present

time and will require an additional reserve unit in the near future. In view of the fact that the other three pumping stations are electrically driven, and the very high wages paid to engineers and firemen, the question of electrification of the main pumping station also comes up for consideration in trying to solve this very complex problem of how to pump more water per dollar than we are now able to do.

Our present method of purification by long storage is working in its most effectual way, and, while it is thoroughly satisfactory from a bacteriological and chemical point of view, the fact remains that we cannot produce a better color on the average than 35. It is only a matter of time until this will be considered unsatisfactory by the citizens of Lynn, and the question of further purification by filtration must arise.

It is, therefore, because of the number and scope of the problems yet to be solved, in the making of Lynn's system thoroughly modern and efficient, that the writer has called this paper merely a report of progress.

Discussion.

Mr. Caleb M. Saville. Mr. Newsom, what is included in the cost to Saugus for that 5.1 cents per hundred cubic feet? What does Saugus get and what does Lynn do?

Mr. Newsom. Saugus merely gets water in bulk at the town line under pressure. The city of Lynn does nothing further than to read those two meters at the town line and send them the bill.

Mr. R. C. P. Coggeshall. What type are those meters?

Mr. Newsom. The larger one is of the current type, and the smaller one the disk type.

Mr. Lincoln Van Gilder. About how much water are you supplying to the town of Saugus through those meters?

Mr. Newsom. A little more than 600 000 gal. a day.

Mr. Saville. How does that 5.1 cents compare with your cost of maintenance and operation?

Mr. Newsom. The figure of 5.1 is entirely separate from the cost of supplying water in the city of Lynn, because it contains no items in connection with the distribution system in Lynn except the charges on two mains going to the town line. So that it is merely the cost of delivering water into our equalizing reservoir plus charges on those two mains.

Mr. Saville. May I ask how you arrived at 5.1 cents as the proper charge?

Mr. Newsom. The items included are, first interest on the normal net bonded indebtedness of the department — we have charged it that way rather than on the value of the works because we desired to assume, in order to be perfectly fair, that the town of Saugus in the past had paid its proportional part, and in so doing had done its part towards the retiring

of such indebtedness as had been retired; so that we charged them interest merely on the average net bonded indebtedness which we expected to have in the next five years. We then charged them, in addition to that, depreciation on the works, which we arrived at after our valuation study, and a charge for extensions to the supply system and the cost of operation in the collection and pumping of the water to the equalizing reservoir.

Mr. Charles W. Sherman. Mr. President, I wish Mr. Newsom would tell us about his experience with these meters at the town line. We have generally been told that the underwriters do not favor meters with moving parts where fire supply is to be taken from the pipes. I understand that this supply to the town of Saugus is a regular municipal supply, including fire protection, and I would not have supposed that he could have furnished it through the type of meter which he refers to.

Mr. Newsom. The reason that the type of meter was not objected to is the fact that the town of Saugus does not depend upon Lynn pressure for fire protection; it has a standpipe of its own, and a set of pumps that it fills the standpipe with, which produces a somewhat higher pressure than the Lynn pressure. The standpipe is turned into the Saugus system by the operation of electric valves in times of fire, and check valves beyond the Lynn meters close and prevent the water coming back into Lynn, so that water from Lynn's supply would only be required after their standpipe had been exhausted, which would be after a good many hours. Both of these meters are on by-passes, and we should have plenty of opportunity before that time came to open the main line valves and let the water in directly.

HIGH-PRESSURE FIRE SYSTEM FOR ATLANTIC CITY.

LINCOLN VAN GILDER.*

[*Read March 10, 1920.*]

The first real movement for high-pressure fire protection in Atlantic City was started about fifteen years ago, but, like many another good thing in advance of the times, it didn't survive the agitation.

After several revivals and two disastrous fires, one of which cost six lives, the project was taken up in earnest and the first installment is now in commission.

The real starting point was the total destruction in August, 1916, of a block of frame stores at Pennsylvania Avenue and the Boardwalk, owned by the then mayor, William Riddle. During this fire the employees of the Hotel Chalfonte ran a line of hose from their own 1 500-gal. fire pump as an auxiliary, which did such good service that the manager, Mr. A. T. Bell, conceived the idea of combining the pumping energy of all the beach-front hotels into one general system, the mains and hydrants to be installed and maintained by the city.

The proposition being favorably considered by the Board of City Commission, and endorsed by the leading property holders, the Chamber of Commerce, and the Hotel Men's Association, was referred to the writer for an opinion as to its practicability, approximate cost, and general layout.

On the assurance that there were no engineering difficulties other than the security of the main and hydrants on the beach front, and that, with a proper working agreement, concerted action of the various pumping units could easily be obtained, the Water Department was instructed to prepare plans and specifications, all of which were approved by the City Commission and the National Board of Fire Underwriters.

Following the general custom of the department in purchasing materials direct, four contracts were awarded, as follows: Pipe and fittings, U. S. C. I. Pipe and Foundry Company; valves, Rensselaer Valve Company; hydrants, R. D. Wood & Co.; installation, M. B. Markland (a local contractor).

Planning for a maximum working pressure of 300 lb., Class G, A. W. W. A. pipe was selected, and as the experience and experiments of other cities — notably New York, San Francisco, and Boston — had shown the value of lead joints, the New York joint was selected.

All line joints were poured with pure lead.

* Engineer and Superintendent of Water Works, Atlantic City, N. J.

Short hydrant branches were calked with an alloy of 95 per cent. lead, 5 per cent. tin.

Joints so made and tested at 400 lb. without bracing or backfilling showed no trace of yielding. One joint in an 8-in. hydrant branch poured with pure lead yielded perceptibly under 400 lb. pressure; it was immediately taken out and re-poured. The contractor's foreman never forgot the tin after that experience.

To provide the greatest possible protection against the corrosion due to moisture and salt all valves and hydrants were trimmed and bolted with bronze.

Valves were Rensselaer high-pressure design, made to withstand 650 lb. hydrostatic test. Twelve-inch valves and under were plain straight stem. Twenty-inch valves, bevel gear; gears covered with water-tight oil cases to prevent contact with fine sand and salt water. All valve stems, manganese bronze.

The high values and hazardous business along the Boardwalk, together with the difficult location from a fire-fighting standpoint, required great care in the location of hydrants, and because they would be so placed as to put the valves below salt-water level it was necessary to build all working parts of bronze or other non-corrosive material.

To insure easy working under the maximum pressure, pilot valves were provided that seat on the underside of the main valve. By this construction the valves were readily operated under the test pressure of 650 lb.

Street hydrants are built for 4-ft. trench. Boardwalk hydrants set at mean low water and operated from the Boardwalk deck have a maximum length of 17 ft. 9 in. from center of branch to center of nozzle. To make hydrants interchangeable, the extra length is made by inserting a cast-iron distance piece between the upper barrel and the elbow with stem length to correspond.

All hydrants are 10-in. barrel, with 8-in. branch, four $2\frac{1}{2}$-in. hose nozzles with independent nozzle gates and with shut-off gates on branches. Nozzles are National Standard thread. Low-pressure hydrants for engine service are 6-thread, and adapters with pressure gage and automatic relief are carried by all engine and hose companies.

The main line under the Boardwalk is 20 in. diameter, about 6 500 ft. long, with two hydrants at each intersecting street and one midway of each 400-ft. block.

All cross-street mains are 12 in. diameter, with hydrant spacing averaging about 150 ft.

Pressure for the system is furnished by the underwriter's fire pumps of eight of our largest hotels, seven of them located on the beach front. These pumps all take water from the adjacent distribution mains and deliver direct to the high-pressure mains.

The maximum pumping capacity is about 11 000 gal. per minute, at

150 lb. pressure at the pumps, and as the latter are so widely distributed over the system the friction loss in the high-pressure mains is negligible. This will also apply to suction with a little strengthening of the distribution system in two places.

At the last semi-official test we had no difficulty in maintaining a satisfactory pressure on 22 lines of hose, with a discharge of about 8 000 gal. per minute computed from Pitot readings.

Domestic pressure, 40 lb., is held in the high-pressure mains at all times through by-passes, and at the last test working pressure at the plugs was raised in $1\frac{1}{2}$ minutes from the signal to start, and this with no previous warning to any one.

Fire alarms are installed in all engine rooms, and on signal every fire pump must be started and pressure held to the limit of its ability.

Every hotel on the system has twenty-four-hour service every day in the year, with eight-hour watches. Every boiler plant has capacity to operate its fire pump together with normal house service, but in the event of falling steam pressure the latter must be curtailed or entirely suspended if necessary.

For beach front service, apparatus is run on the Boardwalk, thus giving the shortest possible leads, the quickest service, and the most advantageous points of operation.

Power-house piping is so arranged that any pump in the system can deliver to any other power-house, thereby insuring every coöperating hotel an ample fire-fighting supply if its own engine room has to be abandoned. Arrangement is also made for using the reserve house tank and well supply in the event of shortage in the city mains.

The cost of the system to date is about \$225 000, involving fixed charges for interest and sinking fund of about \$13 500, while the reduction in insurance premiums has decreased fully \$40,000.

The present or experimental installation has been so satisfactory from every angle that its extension in the very near future is virtually assured, and this extension, as proposed, will cover the entire high-value part of the city, will immediately add four large power-houses, and reduce premiums to such a point as to make it a high-class business investment rather than a liability.

Discussion.

Vice-President Brush. I should like to ask, Mr. Van Gilder, whether you used the tin and lead alloy where you had bends in the mains.

Mr. Van Gilder. In places where we had 45- to 90-degree bends we would put in the ordinary lead joints and back them heavily with concrete thrust blocks.

Mr. Chase. Why do you run your test pressure so high?

Mr. Van Gilder. It was all built for 300-lb. working pressure.

And I would say right here, although I did not put it in the paper, that the original intent was that before the system was finally considered complete the city should build and maintain its own power-house. At that time we will put in pumps for a working pressure of 300 lb., but 150 lb. is the maximum we are able to deliver at the present time.

Mr. Chase. Have you found any need of going above that?

Mr. Van Gilder. We have not as yet. We have a constant fire-fighting service of 150 lb. at the pumps.

Mr. Chase. Do you think you could handle any more pressure?

Mr. Van Gilder. With nozzle holders; not without. We find now we have all the men can hold by hand. The object of putting in the heavy pressure is that we have rather a dangerous situation. We have close buildings, a great many of them frame, and it will be years before they will be removed. The idea is that with a heavy stream in the form of a water gun we could batter the buildings down in places.

Mr. Chase. Could you do that with 150 lb.?

Mr. Van Gilder. I hardly think we could; we might possibly be able to do it. We are experimenting on that line now, to see whether we can or not.

Mr. Chase. Have you ever done anything with the 3-in. hose?

Mr. Van Gilder. Yes, we are using a 3-in. hose almost exclusively with $2\frac{1}{2}$ coupling. I will state right now that the last time we had this thing actually in use we had a fire two blocks away — two 400-ft. blocks — from the nearest hydrant; we ran two lines of hose, and including kinks on the lines, and getting up an alley into working position, we had on one of those lines about 1 000 ft. of hose. We used the 3-in. hose and got a fire-fighting stream at the nozzle 1 000 ft. away.

Vice-President Brush. Was any arrangement made, Mr. Van Gilder, with the fire insurance interests as to a reduction to be granted on the completion of the system?

Mr. Van Gilder. We couldn't do that, because there are several other elements which enter into it, — the construction of the buildings and the general manner in which the town is kept cleaned up, and all.

I must tell you another significant thing. About the time we had gotten this in shape so that we could use it, there was a general raising of insurance rates all over the state of New Jersey. The rate throughout the state went up 10 per cent. Every other city in New Jersey had gone up 10 per cent. but Atlantic City fell 2 per cent. because of this high-pressure system. And we confidently expect another 10 or 15 per cent. reduction when we get the next part of the contract done; but they won't give us definite figures.

Mr. Richard D. Chase. Can you tell us, Mr. Brush, what they are carrying on the high-pressure fire-service systems in New York and Brooklyn now, on the first alarm?

Vice-President Brush. In Brooklyn, on the main high-pressure

system, which is that portion which covers all our manufacturing and dry-goods district, — the other system being our Coney Island system, which is entirely separate, — we carry the full scale pressure, which is equivalent to 100 lb. That is maintained constantly, and the firemen use that on the first alarm. That has been in effect now for approximately two years,— a little over two years, two years and a half. Before that, in Brooklyn, they called for 75 lb. on the first alarm, and then it would be raised as the firemen desired.

In Manhattan the firemen have always asked for 125 lb., and we carry the Croton pressure, which is only a few pounds, 25 lb., on that system, until the alarm comes in, and then the pumps are started immediately and raised to 125. Very seldom are we called to furnish over 150 to 175 lb. We have been called upon to furnish up to, as I recall, 250 lb. We have never been called upon to operate more than one half of our entire capacity in Manhattan. That capacity for each of the two stations is the equivalent of the 6 pumps, each of which has a nominal output of 3 000 gal. a minute against 300 lb. pressure, and under 200 lb. will run about 5 000 gal. a minute.

BOATING AND FISHING IN PONDS AND RESERVOIRS USED AS SOURCES OF WATER SUPPLY.

X. H. GOODNOUGH.*

[*September 8, 1920.*]

One of the most serious difficulties with which water-works officials and health officers have to contend is the enforcement of necessary sanitary regulations for the prevention of the pollution of water-supply reservoirs. This is especially true of that most serious source of danger which results from the use of such reservoirs for boating and fishing.

If present tendencies continue, unless the public can be awakened to the situation, many naturally pure waters are likely to become contaminated, and there is grave danger that in places where the public is now getting the benefit of the very best uncontaminated drinking water recourse will have to be had to methods of purification or sterilization, and the uncertainties of the human element will be introduced in order to make the waters safe for drinking. Where there is now an almost ideal condition as shown by actual death rates for water-borne diseases, an uncertain state of affairs is sure to arise in a field where uncertainties are most to be deplored, — in connection with the public health. With the growth of knowledge it is not to be doubted that the public will eventually protest against the use of polluted waters, whether purified or not, as is indicated by the attitude of the people of Lawrence, who appear to be ready to expend large sums of money in order to avoid the necessity of drinking the polluted water of the Merrimack River, no matter how well purified it may be.

Year after year bills are presented to the legislature to authorize boating and fishing on ponds and reservoirs used as sources of water supply, and as time goes on their advocates become more and more insistent in their appeals for such privileges. The Department of Public Health and the water departments of the various cities, towns, and districts are constantly urged to grant such privileges, and, as one water commissioner has stated it, speaking of his own city, —

> ". . . The political influence grows and grows, until it has practically all the political authorities behind it. With a population of 70 000 they would rather endanger these lives to gratify the wishes and pleasures of one tenth of one per cent., and yet this number is allowed to jeopardize the health of all the others. . . ."

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* Director and Chief Engineer of the Department of Sanitary Engineering, Massachusetts State Department of Public Health.

The average layman, including the average legislator and member of a city government, understands but little of the real nature of water-borne diseases and the means by which the germs of disease may be conveyed through the medium of drinking water to water takers long distances from the point of contamination. Furthermore, the more recent of the great water-borne epidemics of typhoid fever in New England occurred more than half a generation ago and has no doubt long been forgotten except by the comparatively few engineers, sanitarians and water-works officials whose professions or duties require a special knowledge of the subject.

To the average man who desires to fish in a water-supply reservoir it seems incredible, if not wholly absurd, that danger to any one's health might result from allowing him to fish for a few hours occasionally in a water-supply reservoir. When his request for such a privilege is denied, he is naturally unprepared to accept the reasons given for such denial, and often seeks to have the rules set aside in his favor. The effort to have the rules set aside has thus far been confined largely to sanitary regulations relating to great ponds as distinguished from other sources of water supply, the reason brought forward being that the great ponds were in the early days of the settlement of the state set apart for the use of the public. Of course it has been decided by the courts, time and again, that the legislature could grant the use of such ponds for specific purposes like water supply and authorize the enforcement of sanitary regulations under the police power of the state for their protection, and the plea as to the public right of fishing in great ponds is adopted merely because of the possible advantage such an argument may have in obscuring the real issue. It cannot be doubted that, if rights to fish in great ponds were to be granted, pleas would then be made for the rights to fish in artificial reservoirs, possibly because these reservoirs had replaced streams in which fishing was formerly carried on.

To further aid this plea various arguments are commonly brought forward, by the advocate of the fisherman, which will not stand much scrutiny. He believes, or affects to believe, that the reservoir in which he wishes to fish has become so filled with fish that they are a detriment to the quality of the water. This belief is sometimes strengthened in the minds of the general public in cases where the water, as sometimes happens, is affected by a noticeable taste or odor. Such tastes and odors, which are often described as fishy, are sometimes attributed by those unacquainted with their cause to the presence of an excess of fish. Of course every water-works man knows that such tastes and odors are nearly always caused by microscopic organisms, certain kinds of which when present in sufficient numbers impart to water a noticeable and sometimes disagreeable taste and odor. Every one acquainted with the subject knows that they are harmless, and that their appearance in water is not connected in any way with the presence of fish therein, since they will grow in water in practi-

cally any receptacle exposed freely to the light where no fish are ever present. Another claim often made to urge the desirability of allowing fishing in reservoirs is that the presence of fish results in the pollution of the water, and that the fish should be removed for that reason alone. This claim is hardly worthy of serious attention. Concerning it, however, Professor Rosenau in a report to the water board of the city of Fall River made the following sufficient answer:

". . . Fishing takes out a certain number of fish during the short season it is permitted; the few fish thus hooked, however, have little influence in decreasing the total number of fish in the pond, for it is a well-known law of nature that thinning out the number of a species gives the survivors an easier time to find a livelihood; in other words, the multiplication of the species is favored by the thinning-out process. In any event, the number of fish in the pond will always be limited by the amount of available food, and a better way to diminish the number of fish is to prevent organic pollution which directly and indirectly furnishes sustenance for aquatic life.

"In my judgment, the fish in themselves do not pollute the water to any undesirable or even appreciable extent. It is not conceivable that the few fish taken out at the wall [in North Watuppa Pond] could materially diminish the number of fish or appreciably diminish the pollution of the pond. Even though the pond were overstocked with fish it would not render the water as undesirable as the urine or feces from one person with typhoid fever, dysentery, or cholera, or the spittle from a person having tuberculosis. In other words, practically all the infections serious to man which enter a drinking water come from man and not from fish. Owing to the habits of fish, the general effect of their presence in the water would be rather to keep the pond clean than to soil it. . . ." (*From Thirty-Ninth Annual Report, Watuppa Water Board, January 1, 1913.*)

With regard to other animals, no claim has thus far been advanced that they pollute reservoirs, excepting in the case of birds, which did cause the serious pollution of Spot Pond several years ago. The source of the trouble was the gulls who in the winter or early spring would fly inland from the mud flats on the coast and settle in the waters and upon the rocks in Spot Pond. Means were quickly found, however, to prevent contamination from this cause. It should be added that the pollution chiefly feared was that carried upon the bodies of the gulls themselves, who obtain their food in part at least in the polluted waters of nearby harbors. Pollution from their excreta also is of course objectionable, but, as Dr. Rosenau says, "practically all the infections serious to man which enter a drinking water come from man."

In recent years a somewhat more plausible claim has been made that fishing should be allowed in order to increase the food supply, regardless of the fact that the value of the food obtainable in this way is insignificant as compared with its cost. However tenuous or absurd a reason may be presented to a governing body to back up a petition for permission to fish in a water-supply reservoir, it is sure to have many advocates and few or

no opponents except the officials upon whom rests the responsibility of preventing the pollution of the water supply and protecting the public health, and water-works and health officials whose duty it is to protect the interests of the great public are often marks for unfair and unreasonable criticism.

It is desirable, under the circumstances, that the causes which have led to the adoption of the present regulations for the sanitary protection of water supplies should be reviewed to determine whether these rules should be modified — or "liberalized" — as the fishermen desire, or whether they should be maintained or made even more stringent. It is desirable, in the first place, to review briefly some of the experiences in the past upon which the existing regulations are founded, since there are indications that the lessons which they have taught are in danger of being forgotten, not indeed by members of this Association but by those on whom the public depends for its protection, — that is, legislators of our states and municipalities. Furthermore, it is desirable that they should be reviewed for the benefit of the comparatively small number of individuals who are constantly seeking to break down essential sanitary regulations.

As one water commissioner has stated it, "We all know that boating and fishing lead to pollution." This will be realized more fully if we remember always that there are persons who are naturally insanitary in their habits, but who are entirely unconscious of it, and that there is of course a very large number who have no comprehension of the relation between filth and disease. If boating and fishing on reservoirs are allowed, there cannot be the slightest doubt but that pollution will occur, and there is no way of controlling it or stopping it except by preventing this practice.

Pollution of a water supply has been generally considered most dangerous on account of the epidemics known to have resulted therefrom. Typhoid fever is still the most important measure of dangerous pollution, but, while this disease will naturally be considered most in a review of the history of the results of pollution of water supplies, occasion will be taken later to show that there are other and more subtle pollutions which affect the public health. Typhoid fever does not necessarily come from typhoid patients; it often comes from typhoid carriers, and epidemics are often caused by persons who do not know that they have the disease.

One of the first of the great epidemics of typhoid fever in this country where the cause was definitely ascertained was that which occurred in 1885, in Plymouth, Pa. The epidemic was traced to a single case of typhoid fever, where the typhoid excreta were deposited near the edge of a reservoir in the winter season and subsequently washed into the water with the first thaw. All classes of people were attacked in all parts of the town, until, before the epidemic ceased, out of the 8 000 inhabitants 1 104 contracted the disease and 114 died. Dr. Taylor says of it in his report:

". . . [This epidemic] was one of the most remarkable ones in the history of typhoid fever, and taught important lessons, though at a fearful cost. One is, that in any case of typhoid fever, no matter how mild, or how far removed from the haunts of men, the greatest possible care should be exercised in thoroughly disinfecting the poisonous stools. The origin of all this sorrow and desolation occurred miles away on the mountain side, far removed from the populous town, and in a solitary house situated upon the banks of a swift-running stream. The attending physician did not know that this stream supplied the reservoirs with drinking water. Here, if at any place, it might seem excusable to take less than ordinary precautions; but the sequel shows that in every case the most rigid attention to detail in destroying these poisonous germs should be enjoined upon nurses and others in charge of typhoid fever patients, while the history of this epidemic will but add another to the list of such histories which should serve to impress medical men, at least, with the great necessity for perfect cleanliness, — a lesson which mankind at large is slow to learn." (*From "Typhoid Fever," by George C. Whipple.*)

Concerning this epidemic Professor Whipple, in his book on Typhoid Fever, states that it "deserves first mention, partly for the reason that it was one of the first large epidemics where the cause was definitely ascertained, and partly because of the influence which the lessons taught by it have had on sanitary science in this country." He further states,—

". . . The epidemic is interesting to bacteriologists from the fact that it throws some light upon the ability of the typhoid bacillus to survive the apparently unfavorable conditions of winter. Some of the bacilli at least must have lived and retained their virulence in the frozen fecal matter for many weeks."

In the early spring of 1901 an epidemic occurred in New Haven, Conn., which was traced to the infection of the water of Dawson Lake, so called, a storage reservoir having an area of 60 acres, a capacity of 300 million gallons, and a watershed of 13.6 square miles. On this watershed there was no direct sewage pollution and the population was exceedingly small, amounting to only about 25 per square mile. Typhoid fever occurred in a house about half a mile from one of the tributaries of the stream which feeds the reservoir, and the excreta were thrown into a shallow privy vault 325 ft. from the brook and 40 ft. above it. In a spring thaw infection from this source was washed into the stream and thence flowed to the reservoir, through which it passed and entered the supply pipes of the city. It seems inconceivable that a large reservoir could have been so thoroughly infected from so remote and comparatively so slight a pollution. Nevertheless, the epidemic resulted in 514 cases of typhoid fever, among those to whom the water was supplied, and 73 deaths.

At Butler, Pa., an epidemic occurred in the latter part of 1903, when between November 1 and December 17 there were 1 270 cases of typhoid fever and 56 deaths in a town which had at that time a population of about 16 000. Cases of typhoid fever existed on the watershed of the

stream from which the water supply was drawn, and, while the specific source of the epidemic was not discovered, it is evident that water polluted by typhoid germs from one or more of these cases was pumped to the distributing reservoir, whence the water was supplied to the town. In this case the water, which was taken from a stream on which there were storage reservoirs above, was ordinarily passed through a filter, but shortly before the epidemic began, in the course of some alterations that were being made in the pipe connections at the pumping station, the filter plant was put out of service, and ten days after the filter was shut down the epidemic began.

In the winter of 1903, Ithaca, N. Y., the seat of Cornell University, having at that time a population of 13 156, was visited by a severe typhoid epidemic, in the course of which 1 350 cases of typhoid fever occurred, and 82 deaths. More than 500 homes were visited by the disease. Hundreds of the students at Cornell University left town, some of them ill with typhoid fever, scattering the disease elsewhere, and, in fact, a secondary outbreak due to this epidemic resulted from the infection of a well, producing 50 cases of typhoid fever and 5 deaths. The water supplies which became contaminated were taken from small reservoirs on streams of considerable size, known respectively as " Six-Mile Creek " and " Buttermilk Creek." At the time of the epidemic a new dam was being constructed on Six-Mile Creek above the water-works intake, and one theory advanced as to the cause of the epidemic was that the excreta from a possible case of typhoid fever among these laborers may have caused the epidemic. No proof of the existence of such a case was found, however. Another possible source was a gang of laborers working near the stream three miles above the intake, where one of the party was a man known to have had the disease. Whether some of these cases or some unknown case was the active agent in causing the epidemic was not determined, but that the water in some way became affected cannot be doubted. The important point is that here, as in the case of Butler, Pa., was a great epidemic resulting from a cause so obscure that it was not ascertained.

Three years after the Ithaca calamity came the great epidemic at Scranton, Pa., which occurred in December, 1906, and caused 1 155 cases of the disease and 111 deaths in a manufacturing city in eastern Pennsylvania containing 119 000 inhabitants. The water supply of the city at that time was taken largely from a storage basin known as the "Elmhurst Reservoir," which had a capacity of about 1 400 million gallons. In some way this reservoir became infected with typhoid bacilli in November, 1906, but the fact of the infection of this reservoir was made clear by studies of the epidemic and by the analyses of the water, and it is believed that in at least one sample of this water the typhoid bacillus was positively identified. There were several opportunities for infection of the reservoir, and suspicion was especially directed toward the lines of the Delaware, Lackawanna & Western Railroad, which crossed and re-crossed the brook above the reservoir, thus affording opportunities for contamination from

the passenger coaches or from the track men. A most interesting fact about this epidemic is the demonstration that a great reservoir holding 1 400 million gallons of water can become so thoroughly infected with the typhoid bacillus as to cause a great epidemic. A further remarkable circumstance is that the infection resulted from a source so obscure that it was not discovered, and that the slight pollution which might have resulted from the passage of passenger trains through the watershed was held to be a possible cause of the outbreak.

It may be urged that there is no evidence to show that any of these great epidemics were caused by fishing in a reservoir, but that is not the point. The point is that these epidemics were caused by the pollution of a water supply by typhoid germs, and that in many cases the pollution was so obscure that it was never definitely ascertained.

A study of these and other epidemics establishes the fact that typhoid bacilli in water may be carried great distances and retain sufficient virulence to produce typhoid fever. At Millinocket, Me., a typhoid epidemic caused by a polluted water supply resulted in 200 cases of typhoid fever and 16 deaths. The remarkable thing about this epidemic is its most unfortunate sequel. Professor Whipple, from whose book, "Typhoid Fever," the summaries of the foregoing epidemics have largely been taken, describes the sequel to the Millinocket epidemic as follows:

> ". . . The sewage of Millinocket emptied into the Millinocket River and passed down into the Penobscot. Bangor, 84 miles below, used the river water imperfectly filtered, and so did the cities of Old Town and Brewer. In each of these places epidemics of typhoid fever occurred during the months of April and May. In all there were more than 600 cases; in Bangor alone, there were 36 deaths.
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> "The far-reaching effect of the 'accident' at Millinocket is seen from these facts. One cannot help wondering if the time will not come when some one will be held responsible for such 'accidents.'"

The length of time typhoid germs will survive in water has been variously estimated. That they will travel long distances in water is well known. It is believed that typhoid germs discharged into the Potomac River at the time of the Mount Savage, Md., epidemic traveled down the river 185 miles and caused typhoid in Washington. Concerning it Professor Whipple says, —

> ". . . It is believed that this outbreak at Mount Savage caused an infection of the Potomac River water in the city of Washington, 185 miles down stream, where there was an unusual increase in the number of deaths from typhoid fever during September. If this were true, — and the figures seem to indicate that it was true, — the typhoid fever bacilli must have successfully passed down the acid waters of Jenning's Run and Will's Creek, down the Potomac River for 185 miles, and through the reservoirs into the service pipes. . . ."

In the foregoing statements reference is made only to the most promi-

nent epidemics and those which throw light on the most important phases of this subject. These statements show —

1. That a very slight pollution by typhoid fever germs may infect reservoirs of very large capacity sufficiently to cause great epidemics of typhoid fever.

2. That the typhoid germ can survive the severe winter weather of a northern climate and retain its virulence.

3. That the germ can be carried long distances in water, and may survive through many weeks of time.

It has already been noted that in some of the epidemics the exact cause was never discovered; and this fact brings up another discovery of modern sanitary science relating to this disease, namely, that there are typhoid carriers, so-called, who, though apparently in good health, are capable of spreading the disease. Professor Rosenau in his book, "Practical Hygiene" (page 436), commenting on this fact, states, —

". . . An apparently well person is capable of infecting a water supply to a greater extent and with less optical evidence, or none at all, by a discharge of urine into a watercourse than an evidently sick one by a deposit of his feces into it or upon its banks. Experience has shown that about 4 per cent. of all typhoid patients become what are known as chronic carriers of the disease, and this condition may persist over a long period of years. . . ."

Furthermore, there are so-called walking cases of typhoid fever, — that is, cases so mild that the patient is never obliged to go to bed, and there are others who are infected for a period of several weeks before finally coming down with the disease. Where numbers of persons are allowed to resort to ponds and reservoirs for boating and fishing there will inevitably be carriers or possibly walking cases among them, and the infection of the water supply is not only possible but probable. Water boards and superintendents cannot subject a man who comes for a permit to fish to an examination to determine whether or not he is in good health; and any man could get a permit, even though he is a typhoid carrier, if he is not ill and is unaware that he carries the germs of the disease.

The experience in Massachusetts of the effect of allowing boating and fishing on water supplies is limited because very few water supplies have been so used to any extent for many years. In the few cases in which ponds have been thrown open to the public by the removal of restrictions or by the granting of licenses, however limited, there have been enough cases of extreme and disgusting pollution to furnish experience of what would occur if this practice should be made general. The only notable outbreak of disease traced to fishing in a pond or reservoir as the probable cause was an epidemic of gastroenteritis in Peabody, in 1913. In this epidemic about 500 cases of illness occurred, but no deaths, and the epidemic was perhaps exceptional in the fact that it was not followed by typhoid fever as is usually the case.

In another town there occurred, a few years ago, a sudden outbreak of a dozen or more cases of typhoid fever occurring in all parts of the town, and all of them appearing within ten days to two weeks after the Thanksgiving holiday. The water supply in this case was taken from a running stream half a mile below a pond formed by a group of springs at a time when the flow of water was in excess of the quantity of water used by the town. The watershed was uninhabited, but a number of empty cartridge shells about the shore of the pond and along the stream above the intake indicated that the place had recently been visited by hunters, from whom it was presumed the infection was derived.

Only a few of the epidemics due to polluted water supply are mentioned here, though typhoid fever and other diseases contracted through polluted water supplies have claimed their victims by the hundreds and even thousands in past times up to comparatively recent years. One other fact must be borne in mind in connection with the prevention of the pollution of water supplies, and that is that typhoid fever is by no means the only disease transmitted by contaminated water. Dysentery and other diarrheal diseases often precede or follow typhoid epidemics, or, as in the case of Peabody, a very serious epidemic may result from contaminated water unaccompanied by typhoid fever, and these diseases are doubtless due to the same general sources of contamination, though to different specific germs.

One of the most remarkable facts relating to the effect of drinking polluted waters was first pointed out by Mr. Hiram F. Mills in his studies of the effect upon the death rate at Lawrence resulting from the filtration of the water, — that is, from the substitution of a filtered water for a polluted one. The reduction in the general death rate was much greater than could be accounted for by typhoid fever alone or even typhoid fever and the other diarrheal diseases. Professor Whipple, referring to this fact in his book on Typhoid Fever, states, —

". . . The reduction of the typhoid fever death-rate following the substitution of a pure water for a contaminated water is often accompanied by a drop in the death-rate from other diseases. Thus, if the five years before and after filtered water was introduced into Albany, N. Y., are compared, it will be seen that the reduction in deaths from general diarrheal diseases and the deaths of children under five years of age were much greater than in the case of typhoid fever. . . . That the reduction of infant mortality and deaths from diarrheal diseases was not due to other conditions seems probable from the fact that in the neighboring city of Troy, where the water-supply was not changed, there was no such diminution during the same period.

"Hazen, in his paper on "Purification of Water in America," read at the International Engineering Congress at St. Louis, called attention to this same fact, that after the change from an impure to a pure supply of water, the general death-rate of certain communities investigated fell by an amount considerably greater than that resulting from typhoid fever alone — indicating either that certain other infectious diseases were reduced more than typhoid fever, or that the general health tone of the community had been improved. . . ."

It follows from this discovery that pollution of a water supply, even though it does not result in an epidemic of typhoid fever, may mean injury to health in other ways.

It has been urged that the danger of injurious contamination is less where the contaminated water of one pond has to pass through another and uncontaminated reservoir before reaching the water-works intake, and this may not be wholly untrue in some circumstances; but the contamination of the great reservoir at Scranton and the reservoir at New Haven indicates that such a condition may not be adequate protection, since, if one pond becomes thoroughly infected, the other would naturally also become infected if the polluted water flows into it. There are cases where the danger of contamination of a pond used directly for water-supply purposes by the pollution of another pond which is its tributary may be remote, but the experiences already described indicate that this condition cannot be relied upon to protect the health of those to whom the water is supplied.

A most instructive example of what may happen when a water-supply reservoir is thrown open for public use has been furnished recently in the city of Haverhill. Pending the completion of certain sewer connections within the watershed of Lake Saltonstall, it was deemed advisable by the State Department of Health that the use of this lake should be discontinued temporarily, at least, until assurance could be had that the water was safe for drinking. The water board had been importuned to grant permits for boating, fishing, skating, etc., on this lake, and at the time when its use had been temporarily discontinued the water board was requested and practically directed by the city government to throw open the lake to public use until it should again be needed as a water supply. The lake is located close to the best residential quarter of the city, and it is interesting to note that more than one of the owners of land in the neighborhood of the lake favored the granting of the petition. In accordance with the request of the authorities, the rules of the State Department of Health for the sanitary protection of the lake were suspended and it was thrown open for public use. The results were just what was expected by those familiar with water-works practice, but wholly unexpected by many if not most of the petitioners who desired the opening of the lake. The lake and its neighborhood became the resort of persons who not only committed gross nuisances, but made the place unsafe and did much damage to the estates in the neighborhood. A few fish were caught from the lake in the beginning, but the supply of fish was apparently quickly exhausted.

This incident shows clearly the result of the unregulated use of a water-supply reservoir for boating and fishing by the public. It will be urged, of course, that such conditions would not follow if boating and fishing were limited, but experience has repeatedly shown that attempts to limit boating and fishing on a water-supply reservoir are generally utterly impracticable. Attempts to limit the number of permits or to discrimi-

nate between applicants are sure to lead to charges of favoritism, and are impracticable. This is well illustrated by a little incident connected with the effort that has been continuously made for many years by certain inhabitants of Natick to secure the privilege of fishing and boating in Lake Cochituate. During the war it was urged that fishing should be allowed from boats in order to add to the food supply, and the Metropolitan Water Board finally agreed to grant ten permits for fishing in Lake Cochituate within limits designated by them, the permits to be given to persons selected by the Board of Selectmen of Natick. No selections were ever made, the reasons being, as stated by a representative of the town before the legislature, that no board of selectmen could survive politically who should attempt to designate a limited number of citizens to be granted such a privilege.

To us in this day the lessons taught by the great epidemics of the past, united to those instilled by many lesser ones, seem self-evident, but they are very far from being so regarded by the boatmen and fishermen who demand access to water-supply reservoirs, and by many of the legislators and city councilors upon whom such demands are urged. If, through the fatuity of legislative bodies, state or municipal, the policy of the strictest sanitary protection of water-supply reservoirs is broken down or impaired, calamities such as those herein recalled and which now seem relatively remote may easily follow. Furthermore, more memorable and far-reaching consequences may result to those directly or indirectly responsible for such a calamity than was the case in the great epidemics of earlier years when sanitary science in its application to water supplies was less developed than is the case at the present day. Very few of the water takers in any community, and especially in large cities, have a thorough knowledge of the water-supply system from which their drinking water is derived, and fewer still are familiar with the requirements of water-supply sanitation. The great majority, if they think of the matter at all, rely upon the city or town government or water company and their officials to see to it that the water supply is properly maintained and adequately protected, and know little of the measures necessary for such protection. Nevertheless, should an epidemic occur as a result of the selfishness or thoughtlessness of those who seek to use water-supply reservoirs for their own pleasure, the blame would rest, not upon the fishermen, but upon the legislators or officials who yielded to their importunities. Already large sums have been collected in damages in cases where injury has resulted from the drinking of polluted waters and where negligence on the part of the municipality or water company or the agents in charge of its water supply has been proved. It is not impossible that in the future individuals may be punished for such neglect, as has happened in the case of those whose negligence has resulted in accidents on railroads and in the operation of other public utilities. So long as the active and enterprising seekers for the use of water-supply reservoirs continue their efforts to secure the special privileges

which they seek, those charged with the guardianship of water supplies must be prepared at all times to meet their arguments. They must point out clearly to legislative bodies the great danger to the many involved in yielding to the selfishness of the few, whether through ignorance or, worse still, through fear of political consequences. Finally, constant vigilance must be maintained by health and water-supply officials and others interested in the protection of the public health, if this growing menace to the purity of water supplies is to be removed. Any attempt to impair the protection of even a single source of supply must be treated as a threat to all and be met by united opposition.

The knowledge of the effect of drinking waters of various kinds upon health is, it must be admitted, exceedingly limited. The injurious effects of certain minerals in water upon health, as well as the fact that some individuals are very susceptible to certain poisons to which others are apparently immune, are well known. With the greatly increased attention now being given by the medical profession to the influence of diet upon health, a rapidly widening knowledge of the effect of the use of various drinking waters eventually must result. In view of this probability it is of the utmost importance to secure the purest waters possible, and to maintain their natural purity by every possible means.

Discussion.

Mr. Albert L. Sawyer.* It seems to me that Mr. Goodnough has presented a very valuable paper, and one which ought to stiffen up the backbones of some of our water boards and give encouragement to those who are trying to protect the water supplies. He referred to the example of Haverhill very accurately in a general way, and, as presenting a specific case of the results of opening lakes used as a water supply to the public, I think it worth while to state more in detail the conditions that we have had since Lake Saltonstall was opened. We have five lakes and one storage reservoir in Haverhill, and one peculiar thing about our city is that they are all situated within the city limits and all of them are within three miles of the center of the city. Two of the lakes are in a residential section of the city, and they are all easily available, so that they present a rather alluring prospect to fishermen and boatmen.

At the request of the water board, the State Department of Health set forth rules in 1901 covering Kenoza Lake and Millvale Reservoir, and in 1912 similar rules covering the other ponds and reservoirs. While we had the rules, but little was done to enforce them, except in flagrant cases. With the growth of the city, however, conditions were found to be so unsanitary that in 1912 boating, bathing, and fishing were absolutely forbidden; and in 1914 certain facts were brought to the attention of the

* Water Registrar, Haverhill, Mass.

board that caused them to prohibit skating. The board has bought a great deal of land, spending over one hundred and ninety-five thousand dollars, and owns practically all the land around Kenoza Lake, our largest source of supply.

The members of the water board have always been unanimous in believing that the rules should be enforced, which has meant a great deal in obtaining the results that we have.

In 1913 an inspector was employed to look after the watershed. He puts practically all his time on this particular work, including Sundays and holidays. The result is that there is no skating or boating, and practically no fishing. The inspector has an automobile, and last year over twelve hundred inspections were made.

During the past five years there have been seventeen prosecutions for violation of the rules, and we have secured convictions in every case. One case of fishing through the ice was appealed to the Supreme Court, and a decision rendered sustaining the State Department of Health in delegating its authority to local boards and holding that the regulations were neither arbitrary nor unreasonable.

While the policy of the water board has had the general support of the public, there have been many, especially those devoted to sports, who have urged that the ponds should be opened for boating and fishing. This was especially true in the case of Lake Saltonstall, where it was felt that the board was holding a sort of dog-in-the-manger position, — not using the water from this lake and yet not permitting the public to avail themselves of it as a source of pleasure. The enforcement of the rules has had the support of the daily papers, as the following editorial from one of the papers will show:

> "February 16, 1919. There is a petition from Haverhill people filed at the State House seeking the passage of legislation to permit fishing and boating in the lakes used as a water supply. This bill should be killed. The people now realize that too much cannot be done to preserve health and fight off disease. Why, then, should any one seek to open the drinking-water supply to fishermen and boatmen? Do the people want the drinking water contaminated? Was not the influenza sufficient peril without inviting germs into the household through the water faucet? When Mr. Justice Rugg of the Supreme Court rendered a decision upholding the rights of the authorities to prevent fishing on Haverhill's lakes he said: 'It requires no discussion to demonstrate that the preservation of the purity of the water supply for domestic uses of the people is within the police power. The absolute prohibition of fishing upon such a source of supply could not be said to be unreasonable under the circumstances.' The State Board of Health says, referring to the Haverhill situation: 'The prohibition of fishing . . . appears sometimes to be a hardship, . . . but the practice of fishing has been found to be a serious menace to the public health.' In view of these facts, what citizen would open our lakes to fishermen?"

The State Department of Health recommended that Lake Saltonstall be not used during the building of a sewer near the lake, and its use was discontinued August 1, 1916. January 23, 1919, the department wrote

us again, in response to our request for permission to use the water, recommending that the lake be not used until further advice. In March, 1919, the mayor and one of the aldermen appeared before the water board and asked that Lake Saltonstall be opened for public use. In April the department definitely recommended that its use as a water supply be discontinued. The water board on May 7, 1919, called the attention of the State Department of Health to the facts and suggested that the rules as applying to the lake should be removed, and May 14, 1919, the State Department suspended the regulations so far as they applied to Lake Saltonstall.

May 16, 1919, the daily paper had the following item:

"Ever since it became known that the State Department of Health was to remove the restrictions, there have been hundreds of people visit the lake and indulge in the sport so long denied. The anglers are fishing with enthusiasm, and, though the official notification had not been received by the water board at the time, stories are told of catches of twenty-one pickerel, and yarns about four- and five-pounders were frequent. The Council and the health board begin to wonder what the result is going to be. It is apparent to city officials that the fishermen will have to be restrained. Most of the land around the lake is private property, and they wonder what the effect will be of loosing so many fishermen."

May 19 two police officers were detailed for duty at Lake Saltonstall, following continued complaints which were received from people residing in that section. There was a complaint that two boys were bathing in their birthday clothes. Mayor Croy made the following statement:

"So many complaints have come to me relative to the loud, vulgar, and profane talk on and around Lake Saltonstall, and the trespassing over lawns and gardens, I want to say that if it is not stopped immediately there will have to be some arrests, and it is liable to bring about the closing of the pond. There will be no more bathing except in bathing suits."

"May 21, 1919. The two officers are being kept busy, for crowds flock to the lake each evening. The crowds are made up of boys and young men. The R. A. Jordan estate which is adjacent to the lake had the appearance of a circus ground last night. A crowd of lads gathered to enjoy themselves, damaging property and tearing up the lawn. Officer Cronin dispersed the crowd. Another crowd started a roughhouse near the Nichols estate, while Officer Lane chased a crowd that was causing a disturbance at Mill Street. A man was stopped from lighting a fire on the Sanders estate."

With the opening up of this one lake came an epidemic of fishing in the other lakes that had been closed, mostly by boys who seemed to have got the idea that everything was wide open.

"May 25, 1919. The *Sunday Record* had a leading editorial headed, 'Close the Lake,' in which they said, 'Lake Saltonstall was opened to the people of the city that it might be of general benefit as a pleasure place. It is fast becoming a public nuisance. In the fortnight which has passed there have been numerous causes for complaint. The rights of the property owners have been violated, acts of rowdyism have been many, and the very character of many of the persons congregating at the lake has been enough to justify closing the waters again.'"

An article in the same issue of the paper was as follows:

"After an agitation of many years, Plug Pond has been opened and there is a regrettable condition existing. Nuisances have been committed, property has been damaged, a quiet locality has been made noisy and disorderly, and the residents have had to hire guards to prevent trespassing upon their property and damage to their buildings. While it is true that respectable people have gone to the lake to fish and have conducted themselves properly, it is also true that the majority have been of a disturbing element. To crown it all, the millions of fine fish, so widely advertised by those who knew, have not been found. A few sickly hornpout have been pulled out, but the trout and pickerel and perch have been conspicuous by their absence. The opening of the lake has been a failure. The children have not benefited. The chief beneficiaries seem to be a gang of boisterous bums who should be breaking stones for the county instead of making themselves a general nuisance."

"June 1, 1920. Dr. Popoff and a delegation, representing residents and property owners on the shore of Lake Saltonstall, attended the meeting of the Council and protested against the rowdyism that prevails there nights."

"June 13, 1920. Lake Saltonstall is to be closed again to public use. Complaints have become so insistent that steps have been taken to have the restriction again put in force. Mayor Croy has been informed that the State Health authorities will close the pond. A requisition was made for a boat for the police department, but it was held up."

"June 21, 1920. The Mayor stated that there is some difference of opinion in regard to closing the lake again. Some are in favor and some against. All but one of those owning property bordering on the lake are in favor of closing it again. It was one of the hottest potatoes I ever picked up, and I am willing to pass the buck over to the water board or to the State Department of Health. As I understand it, the Council has no jurisdiction over it, although we all urged the water board pretty strongly to open the lake. Some people claimed that when it was not used as a water supply its status became simply a great pond and as such the people had a lawful right to use it. The entire shore of the lake is owned by private parties, except at one end, where the water board have their gate house, and at the other, where the city owns a strip of land."

"July 19, 1920. Dr. John F. Croston, chairman of the Board of Health, is indignant over conditions at Lake Saltonstall, and as a result of personal observations and experiences it is likely that he will urge that some action be taken by the board to remedy conditions."

"June 28, 1920. Property owners are indignant at the lack of police activity in cleaning up conditions in the lake section and the failure to suppress rowdyism. Alderman Bartlett, commissioner of public safety, visited the lake to-day and saw and heard enough to satisfy him that the property owners have a just cause for complaint. He is said to have described the conditions as shocking."

The police department finally formulated a plan of protection, and since July 3 there has been an officer on duty from 10.00 A.M. till 10.00 P.M. They started in with two officers on duty at one time, but after a week they obtained the loan of a boat from the water department, and since then one man has been able to look after the lake. The deputy marshal told me, a few days ago, that they now had very few complaints from the residents near the lake.

I went to the lake a week ago, on a very hot Saturday, and found three or four boats and rafts on the water, a few boys fishing, four women swimming at one end of the lake, and at the swimming hole on the other

side probably sixty boys and men in the water or on the shore. There is a great deal of paper and débris where the main part of the swimming is done, which the officer collects and burns. I noted also considerable human excrement, old cans, etc., at intervals along the shore.

The commotion we have had in Haverhill for the past two years, as illustrated by the newspaper clippings, has been due more to the disturbance and nuisance to the residents living near the lake, and there has not been much thought given to the pollution of a water supply, but it must be evident to all of us what a menace such conditions would be to the health of a community that was using the water of such a pond.

Mr. J. M. Diven.* I should like to ask Mr. Goodnough if he can tell us whether tuberculosis has ever been directly traced to this sort of pollution. I could not find anybody that could back me up in saying that tuberculosis could be carried by water.

Mr. Goodnough. I do not think it has been established that it can be.

Mr. Caleb Saville.† Mr. Goodnough spoke in his paper of the total infection of a rather large reservoir, and that opens up a new thought in my mind, because Dr. Houston and others had demonstrated that typhoid fever and other disease germs died after a practically short life in a reservoir. We have thought that a reservoir of ample proportions was one of the most efficient safeguards of a public water supply.

Mr. Goodnough. These facts are as stated in Professor Whipple's book. I suppose it makes a very great difference what the size of the watershed is and what the flow of water through the reservoir is. A large reservoir might have so great a watershed that it would change the water in a week. What Dr. Houston is talking about, and what we all rely upon, is long storage; but I was unable to find what the probable flow through these reservoirs was. One of them was three hundred million gallons and had an area of 13 square miles. This would not probably have a rapid change.

Mr. Saville. The fact of long storage in a reservoir still holds good?

Mr. Goodnough. So far as I know, it does. It depends upon the length of storage, as I see it.

Prof. George C. Whipple.‡ Mr. Goodnough has done well in bringing to the attention of this Association the vexing problem of boating and fishing in lakes and reservoirs used as public water supplies. It is not one of the major sanitary problems, but it is far from being a negligible one. It is also a most troublesome one from an administrative point of view. Practically all sanitarians and water-works officials are agreed that boating and fishing in water supplies is a menace to the security of the sanitary quality of the water, and for that reason should be suppressed

* Superintendent Water Works, Troy, N. Y.

† Manager and Chief Engineer, Board of Water Commissioners, Hartford, Conn.

‡ Harvard Engineering School.

or at least regulated. All are agreed, also, that if boating and fishing are permitted at all the practice should be limited to persons authorized by permit. Differences of opinion exist, however, as to who should have the authority to issue such permits. Some persons prefer to have the matter rest in the hands of the State Department of Public Health.* Other persons apparently prefer to have it left to the local water boards.

Some of the arguments which have been advanced in favor of state control are that the care and oversight of the water used as sources of water supply have been committed to the state department by the legislature; that this department is best fitted by its authority and by its knowledge of sanitary principles to exercise this power; that the local water boards would thus be relieved of a disagreeable duty; that conflicts between the water boards and various local authorities would be avoided; and that the injection of this question into local politics would be prevented. Arguments advanced in favor of local control are that the State Department is not in a position to enforce such regulations as it might make except at great expense; that the issue of permits by the state authorities would be inconvenient to those who desired permits; that the local officials ought to be responsible for local sanitary conditions, especially in those matters which require prompt action, and that the local issue of permits tends to emphasize this responsibility; that the question of issuing permits is not infrequently a matter of distinguishing between persons likely to use the permits in a reasonable manner and those who would not, and that in such matters as these the local authorities are best qualified to act.

As long ago as 1897 the Massachusetts State Board of Health was empowered to make and approve rules and regulations governing the sanitary control of water supplies which include the problem of boating and fishing. In 1907 the legislature gave to the State Board of Health the power to delegate the issue of permits for boating and fishing to local water boards, subject to the recommendation and direction of the State Board. This act has been upheld by the courts. Since 1907, the practice of delegating the power to issue permits to the local water boards has been followed in the case of all cities and towns for which rules and regulations have been made. The state department has usually recommended that no permits be issued for bodies of water from which the water was taken directly for drinking purposes. During the war, when it was believed that unusual precautions ought to be taken, the department issued a general recommendation that no permits for boating and fishing be granted. This applied to all of the water supplies of the state, whether or not rules and regulations had been made. After the war ended, this general recommendation was recalled by vote of the department on July 3, 1919. The announcement of this vote created some misunderstanding. It was intended to mean that the conditions were restored to what they had been

* From 1869 to 1914 this department was known as the State Board of Health; from 1914 to 1919 as the State Department of Health; and since 1919 as the Department of Public Health.

before the war, — namely, that the power to issue permits for boating and fishing was delegated to local water boards, subject to the recommendation and direction of the state department. It was not intended to mean that the doors for boating and fishing would be opened wider than they had been. Because of this misunderstanding among water board officials and persons who desired to secure permits, the Department of Public Health held a conference at the State House on June 15, 1920, which was largely attended by representatives of many of the water boards of the state. The sentiment of those who spoke at this conference was strongly against the granting of permits for boating and fishing, and strongly in favor of having the authority for granting permits left in the hands of the Department of Public Health rather than having it delegated to local authorities. For the purpose of clearing up this misunderstanding, the present status of boating and fishing in lakes and ponds used as sources of water supply has been recently announced by the Department of Public Health as follows:

" The granting or refusing of permits for boating, and fishing in bodies of water used as sources of public water supply has been delegated by the Department of Public Health to the water boards of those cities and towns for which rules and regulations have been established, subject to the recommendation and direction of the Department of Public Health. In view of the facts above outlined, including desires of the water departments as expressed at the conference noted above, but especially in view of the grave danger to the public health involved in boating and fishing upon reservoirs, lakes, and ponds used as sources of public water supply and the necessity of sanitary protection, the Department of Public Health at its meeting on October 19, 1920, voted as follows:

" ' For the sanitary protection of the public water supplies of the state the State Department of Public Health advises that no permits whatever be given for boating or fishing on any body of water used as a source of public water supply from which water is taken directly for drinking or on any body of water kept as an auxiliary source, and that no boating or fishing be permitted on tributary sources, unless with the advice of this department, and then only under such limitations and restrictions as the department shall prescribe.' "

This question of boating and fishing in water supplies is something more than a mere detail of administration, for it raises again the fundamental question as to whether the best results can be accomplished by a state department of public health acting in its advisory capacity or by directly exercising its authority under the police power. The Massachusetts State Board of Health, including its successors, the State Department of Health and the Department of Public Health, has been in existence for more than fifty years. It has been a pioneer in sanitation, and in many ways has been a leader among states. The writer has written a history of its work, and has carefully studied its decisions, and is convinced that the success of its sanitary program has been due in great measure to the fact that it has depended upon its advisory power far more than upon the

frequent direct use of the police power. The character of its scientific staff and the wisdom of its advice have ordinarily been such that no drastic action beyond the giving of advice has been necessary. For any one to act contrary to the advice of the Massachusetts State Board of Health was regarded as a serious matter.

The State Department of Public Health has and ought to have the power to exercise its authority in matters which affect the public health, but the writer holds that drastic use of this power should be limited to cases where actual nuisances exist or where the danger to public health is serious or immediate. In proportion as the danger to health is less, greater dependence should be placed on advisory power.

During recent years a number of our American state departments of health have been given greater latitude in matters which concern water supplies and sewerage than has been the case in Massachusetts. They have been charged with the duty of *approving* plans for water supplies and sanitary works and they have sometimes been given the right to *order* local communities to install sanitary works or to do certain things in the interest of better sanitation. So far as the power to approve plans for water supplies and sanitary works is concerned, there can be little objection to it, because this is a sort of judicial action, the state being the proper authority to see that what is done in one city or town does not injure or encroach upon the rights of other cities and towns.

But, looking at the matter in a broad way, the writer deplores this tendency to concentrate power in the state authorities, and favors a return to the earlier policy of greater local responsibility and greater dependence upon the advisory powers of the state. What is needed from a state department of health is not stricter orders but better advice, and in order to give the best possible advice the state departments should include the very best experts in the country.

It has already happened in the United States that state departments of health have ordered local communities to take action in a way which seemed to utterly disregard local conditions, as well as the financial abilities of the local communities to carry out the orders. The result has been that the orders have been ignored and the reputation of the state department brought into contempt. If state departments of health issue orders, they must be prepared to enforce them. Every order disregarded stands as a tribute to degenerate government. Is not authority without power futile?

Again, if state departments assume the authority to order that a certain thing be done, are they willing or can they be made to assume the responsibility for their acts? Is not authority without responsibility unjust? Does it not lead to autocracy?

There seems to be in the United States a marked tendency toward centralized government. Perhaps it is wise. Perhaps it is necessary. Perhaps the changing character of our population, our growing cities, and

our inefficient local governments demand it. But let us not lose sight of where this policy leads. Let us not forget the earlier traditions of New England, — local self-government, home rule, an educated electorate capable of governing itself. The writer believes that the answer to inefficient local governments is not "Leave it to the state," but "Make the people responsible and show them what to do." Wonderful results will follow the exercise of advisory powers, if the people have confidence in the authorities which give the advice. The state departments of health should be given the necessary resources to employ men of the highest grade and reputation, and they should be provided with all the necessary facilities to study and advance scientific discoveries and their practical application to local problems in order that they may be fit to give the advice expected of the august authorities of sovereign states.

Returning to the question of the enforcement of rules in regard to boating and fishing, the writer wishes to recall to the members of this Association the fundamental principles upon which the care and oversight of the inland waters of the state by the Massachusetts State Board of Health were founded. They have never been phrased better than by Massachusetts' great sanitary statesman, Dr. Henry P. Walcott:

"We propose to clothe the board with no other power than to examine, advise, and report, except in cases of violation of the statutes. Such cases, if persisted in after notice, are to be referred to the Attorney-General for action. Other than this, its decisions must look for their sanction to their own intrinsic sense and soundness. Its last protest against willful and obstinate defilement will be to the General Court." *

* Report of Massachusetts Drainage Commission, 1886, page lxi.

QUICKSAND, — ITS NATURE, BEHAVIOR, AND METHODS OF CONTROL.

BY COL. CHARLES R. GOW.

[*Read September 8, 1920.*]

The term "quicksand" has always exercised a fascinating influence over the imaginative mind, and for ages past it has played a prominent rôle in both fiction and recorded fact.

Mysterious and sinister influences have frequently been ascribed to the presence of "quicksand" when no other reasonable or convenient explanation was available.

An experience covering approximately thirty years, during which time the writer has had occasion to contend with quicksand under a great variety of circumstances, has resulted in the forming of many convictions, both as to its nature and methods of control, which it seems worth while to record for the benefit of those who may encounter future similar problems for the first time.

In what follows, much which may seem purely elemental has necessarily been included in order properly to cover the ground.

Contrary to popular impression, "quicksand," strictly speaking, is not a material, but rather is a condition of a material, which under different circumstances, may possess no such characteristics. Furthermore, quicksand, as such, rarely occurs in nature, but usually is artificially produced by the acts of man.

In seeking a definitition of the term "quicksand," one may find a bewildering variety of descriptions by present and past authorities. In one case the grains are said to be in the form of an impalpable powder; in another they are spherical in shape: again the sand contains some clayey substance, while still others maintain that a quicksand is any sand which will flow with water.

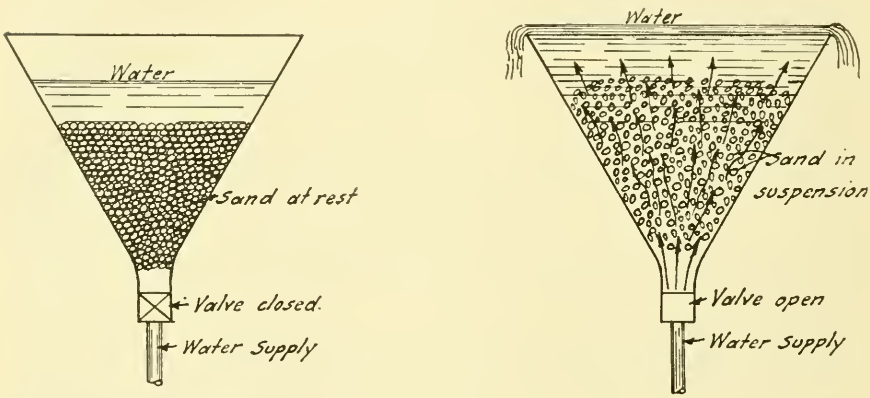
Undoubtedly, some, or all of these characteristics have been noted at times in experiences with quicksand, but none of them is absolutely essential in order to have present the quality of quickness which gives the substance its name.

Any material of a granular nature may become a quicksand if there is an upward movement of ground water through it of sufficient velocity to lift and carry the individual particles. On the other hand, no such material will become "quick" in character unless there is such a flow of water.

One of the best and most inclusive definitions of the term "quicksand" which the writer has ever seen was given about twenty years ago by one

of our fellow-members, — Mr. Allen Hazen, — in a discussion of the subject before the American Society of Civil Engineers wherein he stated that quicksand is, "a sand containing for the time more water than would normally be contained in its voids, and, therefore, with its grains held a little distance apart so that they flow upon each other readily." Such a definition is applicable to any material, irrespective of its composition which manifests the conditions and behavior usually ascribed to "quicksand."

This condition is illustrated in Fig. 1. The left-hand view shows a container partially filled with sand which in turn is submerged in water,



EFFECT OF UPWARD FLOW
ON SAND GRAINS
FIG. I

the water being at rest. The several grains of sand rest one upon another and the voids in the sand mass are identical with those found in dry sand of the same composition except that in this case they are completely filled by the water. In order to displace any individual grain, therefore, it will be necessary to overcome the frictional resistance of that particle upon its adjacent neighboring grains and in the case of an interior particle the adjacent grains must also be displaced more or less in order to free the one in question. Regardless of the shape or size of the individual particles constituting the sand, such a disturbance will require the application of a substantial amount of force.

In such circumstances the behavior of the sand under conditions of loading, excavating, or manipulating, will, to all intents and purposes, resemble the behavior of dry sand.

The right-hand view, however, illustrates what takes place when an upward flow of water is induced in the material. Water admitted through

the pipe at the bottom must find its way to the top through the devious passages formed by the voids in the sand. The friction of the passing water upon the separate grains of sand either actually lifts them as shown in the illustration or tends to reduce the friction of one grain upon the other, thus making displacement of the particles much easier of accomplishment. It will readily be seen that the amount of separation of the particles will depend entirely upon the velocity of the water and hence its upward pressure upon the several grains. In other words, the grains of sand may lose altogether their friction upon one another and be substantially in a state of suspension in the water.

In such a condition the material loses its stability; the several particles offer practically no resistance against displacement; a body resting upon such a mass will sink into it as it would into a semi-fluid material. Furthermore, if the velocity of flow is further increased, the sand may be carried upward with the current and be completely removed from the container.

In order to possess the qualities of "quicksand," the material must approximate the condition illustrated in this view wherein the amount of water contained in the sand mass is in excess of the volume of its normal voids.

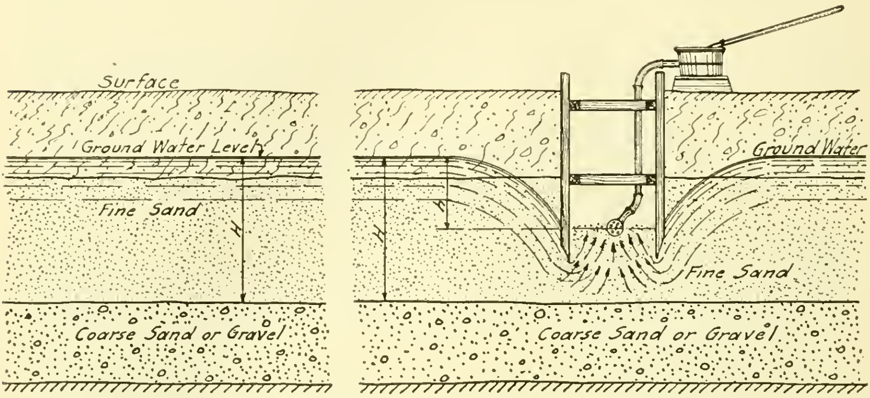
It will be obvious that the smaller the individual particles of sand are the easier it becomes for the water to lift and hold them in suspension. Also the voids, generally speaking, will be smaller and more numerous in this case and the passage of water through them more difficult. The result is, therefore, that fine-grained sand displays the quality of "quicksand" much more readily than does a coarse-grained material.

The writer has seen coarse sand and gravel, however, which displayed all of the characteristics of a "quicksand" under conditions of high velocity of water inflow, but in the main the term is chiefly applicable to sands of extremely fine texture.

Fig. 2 illustrates the unbalanced condition of ground water which occurs when an excavation is made into wet sand by the usual process. At the left is shown the assumed stratification of soil and the normal level of ground water. At any given depth there is a balanced hydrostatic pressure so that no upward flow of water through the material results.

At the right is shown a sheeted excavation which has been carried below the ground-water level with the assistance of a pump which drains the inflow of water entering the opening. The drawing down of the water level at this point results in an unbalanced condition with respect to the surrounding ground water. That in the coarse stratum at the bottom of the section is under a pressure due to the head H. In the area immediately under the excavation, however, the upward pressure from this stratum is resisted only by the pressure due to the head H-h, with the result that there is a flow of water from the coarse stratum upward into the excavated opening. Depending upon the velocity of this flow,

together with the character of the sand, there will result a condition of "quicksand" in the soil underlying the excavation. The illustration also indicates how the water level may be drawn down at either side of the

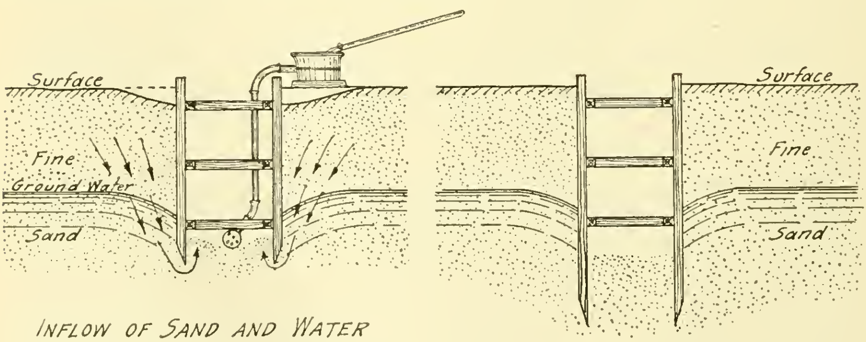


NORMAL CONDITION OF WET SAND

UNBALANCED WATER CONDITION DURING EXCAVATION PROCESS

FIG. 2

excavation, the particular slope of the water-table depending upon the relative draining qualities of the material.



INFLOW OF SAND AND WATER DUE TO INSUFFICIENT PENETRATION OF SHEETING, CAUSING SUBSIDENCE OF SURFACE ADJACENT TO TRENCH

INFLOW PREVENTED BY DRIVING SHEETING TO GREATER DEPTH

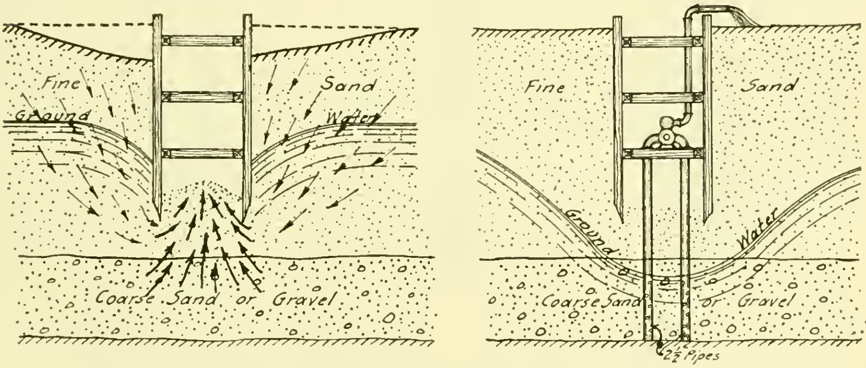
FIG. 3

A common difficulty encountered in excavations into wet, fine sand is indicated in Fig. 3. When the sheeting of the excavation is relatively water tight, as it must be to prevent the inflow of water and sand through its vertical joints, there may result an accumulation of water pressure

immediately behind the sheeting. Unless the sheeting is driven to a substantial distance in advance of the excavation, this pressure may cause a break under the sheeting, allowing the water and sand to flow through the passage thus formed, bringing a considerable quantity of sand from back of the sheeting and leaving a void there which in turn is filled by settlement of the banks above. Thus it sometimes happens in trenches of this character where suitable precautions are not taken to secure a deep cut-off by driving the sheeting well below the bottom of the excavation, that surface objects find their way by settlement down behind the sheeting until they flow into the trench at the excavation level.

It will usually be found to be economical in cases of this nature to employ matched or tongued and grooved sheeting and to drive the same several feet below the required depth of excavation, in order to avoid disturbance of the adjacent banks and the removal of excessive amounts of material.

Under the same conditions of stratification and water pressure shown



BOILING INDUCED BY UPWARD FLOW FROM COARSE STRATUM BELOW TRENCH

BLEEDING COARSE STRATUM TO PREVENT BOILING

FIG. 4

in Fig. 3 an extremely fine-grained sand may assume semi-fluid tendencies due to the upward movement of water in the soil underlying the excavation caused by the water pressure immediately behind the sheeting. In such cases there may be a welling up or lifting of the sand into the trench or pit, just as a very viscous liquid may be expected to act. For this reason a trench left over night may be found the next morning to have filled up again to a depth of several feet.

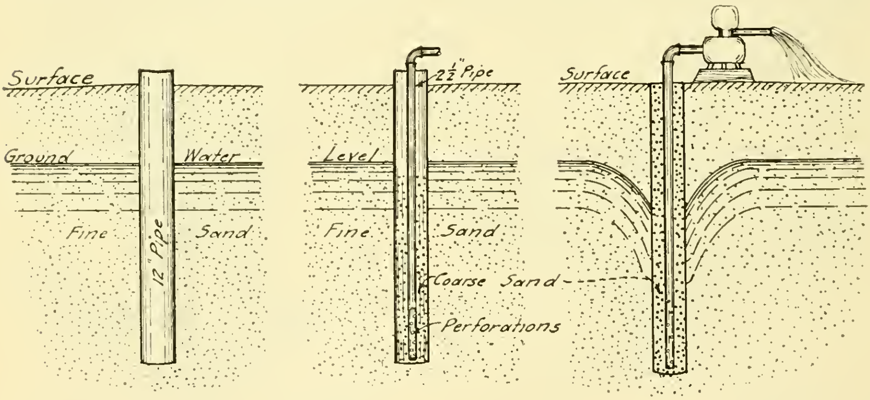
This tendency can be resisted by driving the sheeting deeper and by the free use of gravel or broken stone which forms a surface layer or crust over the sand, permitting the water to escape, but preventing the several small boils whereby the sand is carried upward into the trench.

A more serious cause of trouble from quicksand and its possible remedy is shown in Fig. 4. In this case an upward flow of water from a coarse stratum below, caused by an unbalanced water head as previously described,

carries the sand with it into the trench. The sand displaced by this action is replaced by the adjacent sand on either side, which flows in laterally to fill the crater thus formed. The result is a demoralizing of the surrounding ground surface and an inflow of sand through the bottom of the excavation which may flow in as fast as or faster than it can be removed.

Further driving of the sheeting in such cases is ineffective unless it is carried down to the stratum of coarse material, and even then the boiling of sand and water continues, although the adjacent ground is protected against undermining.

The most expeditious and satisfactory method for handling such cases is by means of the bleeding process illustrated in the right-hand view of Fig. 4. Perforated pipes or well points of sufficient size and number are driven into the coarse stratum and connected by a manifold, as in any



METHOD OF BLEEDING FINE SAND

FIG. 5

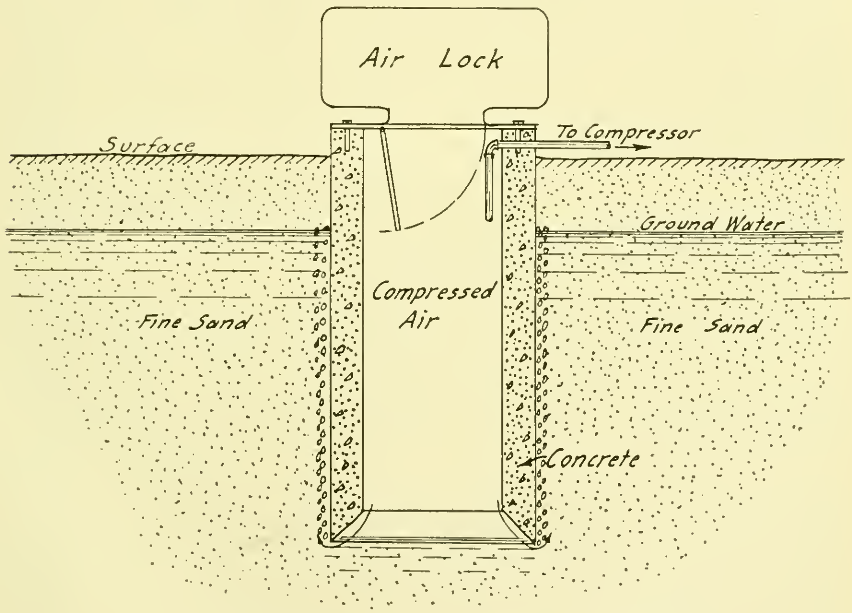
driven well installation, to a pump of proper size. Provided the capacity of the pump and well system is greater than the amount of inflow at the given point, there will result a depression of the surrounding ground-water level to a depth lower than that of the excavation, thus permitting the latter to be carried on in the dry.

This method is relatively inexpensive compared with the cost of handling a bad quicksand trench, and is to be recommended whenever there occurs violent boiling from a lower level.

A somewhat similar but less dependable method of bleeding fine sand when the coarse stratum is missing is shown in Fig. 5. Generally speaking, well points are not effective in fine sand because the amount of water which can be drained by a single point is small, due to the slow percolation through it and the fineness of the gauze screening which prevents the

sand from entering the pipe. To meet this condition, however, large pipes of say 12 ins. in diameter may be driven, into which smaller well pipes are inserted, the annular space between them being filled with coarse sand. If the large pipe is then removed, the coarse sand will collect the water from the fine sand while still holding the latter in place, and will readily deliver the accumulated drainage to the well point in the lower end of the well pipe. If a sufficient number of these installations are connected in a given locality, the water in the fine sand may be drawn down as in the former case.

An interesting application of this method was used by the writer some years ago to secure driven well supplies for two state institutions. The amounts of water required were not large, but there was no coarse stratum available from which to secure the necessary quantity. There were, however, in each instance, areas of fine sand deposit containing water. In these cases cylindrical pits 3 ft. in diameter were sunk to depths of



SINKING THROUGH FINE WET SAND BY MEANS OF COMPRESSED AIR

FIG. 6

approximately 12 to 15 ft. by means of steel cylinders into the wet, fine sand. Two-in. perforated well points were inserted in the center of each circular pit and the opening then backfilled with gravel and coarse sand. The steel cylinders were withdrawn, and after the several well pipes were connected to a pump, a reasonably satisfactory supply of water was obtained. In these cases the locations showing the coarsest of the fine sand deposits were naturally selected.

In sinking excavations to great depths through fine, wet sand, or in those cases where the inflow of water is beyond the capacity of practical pumping operations, resort must be had to the pneumatic or compressed, air process. Such a method is illustrated in Fig. 6. The introduction of air into the workings of a shaft or caisson under a pressure, equal to, or greater than, the hydrostatic pressure at the bottom, naturally forces the water back into the soil and permits access to the same for the purpose of further excavation. The same fine sand which, perhaps, has previously boiled violently under the influence of inflowing water so as to be absolutely unstable and incapable of sustaining any weight, is often found under the pneumatic method to require picking for its removal. No better illustration than this could be had of the fact that it is the upward flow of water and not the material itself which results in a "quicksand" condition.

The use of the pneumatic process has been more or less common in the past for the sinking of deep supply wells. Cylinders, either of steel or concrete, are used as casings, and when such casings have penetrated a sufficient depth into porous material, removable plates covering numerous inlets opening around the circumference are detached, permitting an inflow of water from the coarse stratum.

Fine, wet-sand deposits, which offer almost insurmountable difficulties in the case of open excavations, may usually be tunneled by the use of compressed air with the utmost ease, because, in removing the water, the material becomes both dense and stable.

A few years ago the writer had occasion to sink a concrete chimney foundation 20 ft. in diameter to a depth of 40 ft. through a bed of fine, wet sand. After excavating to the ground-water level, forms were erected for the outer circumference of the foundation and the first 10 ft. in height of the foundation was erected. A working chamber was hollowed out in the under portion and a circular vertical shaft opening 6 ft. in diameter was formed in the center. As soon as the concrete acquired its set the outer forms were stripped, and sinking was commenced by excavating from beneath the cutting edge, more concrete being added at the top as the foundation settled into the excavation thus made. When the sand began to give, evidence of boiling or welling up, two steel lock-heads with doors in them were built into the central shaft opening 6 ft. apart, vertically, and the space thus enclosed was used as an air lock. Air pressure was then applied to the working chamber, driving out the water in the sand and leaving an extremely compact material which required vigorous picking for its removal. As fast as the excavation could be carried down below the cutting edge, the air pressure was temporarily lowered and the concrete mass slowly settled to the bottom. In this manner the bottom of the foundation was carried down to clay hardpan at a depth of 40 ft. below the surface. The working chamber and central shaft were then filled with concrete, leaving a cylindrical monolith 20 ft. in diameter upon which the chimney was constructed.

The entire operation required six weeks for completion and cost approximately $12 per cu. yd., including all expense of every description.

The writer has previously stated that the quicksand condition rarely occurs in nature. Stories of men and animals losing their lives by being "sucked" into quicksand beds probably have their origin in the mistaken application of the term to deposits of semi-fluid mud, silt, or soft clay.

Undoubtedly, there may occur isolated cases in which ground-water rises to the surface through beds of fine sand, thus producing a natural quicksand, although the writer does not recall ever having seen this particular combination.

Several years ago, however, the writer was called into consultation in connection with an upheaval of fine sand and water in the basement of a mill building, which ultimately resulted in serious damage to the structure. A test boring, made at the site, disclosed the fact that there existed a surface layer of very compact clay hardpan overlying a bed of extremely fine sand about 20 ft. in thickness. Immediately under the fine sand was a substantial layer of coarse gravel, containing water under such a head, that it rose in the boring pipe to a height 14 ft. above the level of the basement floor, or several feet higher than the natural ground level in the vicinity. A large brick drain below the basement floor permitted the ready escape of the flowing sand on to a nearby beach.

In order to remedy the difficulty, several 6-in. pipes were driven down to the coarse stratum and their tops cut off just below the basement floor grade. The clear water flowed through the open pipes so freely that the ground-water head was thereby reduced below that required to force its passage upward through the fine sand, with the result that the flow of sand ceased entirely. Incidentally a most excellent water supply was secured to the mill for manufacturing purposes, but at the expense of rebuilding a considerable portion of the building which was undermined before the remedy was applied.

It has been the writer's observation that fine, wet sand in its normal condition will sustain quite as great a foundation load as will the coarse-grained sands. The usual aversion to using fine, wet sand as a bearing material has its chief basis, in the writer's opinion, upon the fact that we usually see such sand in its abnormal and not its normal state.

Some years ago, the writer had occasion to construct some pier foundations upon coarse, wet sand. The test borings indicated a firm layer of sand, but when the excavation had progressed to this point it was found by the inspector that he could readily force a rod into the soil for a considerable depth. Because of this apparent instability, he ordered that the excavation should be carried deeper until satisfactory material was encountered. The foreman suspended work for the time being and allowed the ground water to rise in the pit to its normal level. Upon attempting again to demonstrate the soft quality of sand by means of the same rod, the inspector was surprised to find that he could make no impression upon

the surface of the sand, now that there was no longer an upward flow through it.

It is because of the fact that we are obliged ordinarily to produce an unnatural condition in wet sand in order to expose and examine it, that so many people assume this to be its natural state, while the contrary is in reality true.

A perusal of the building regulations of the several large cities will show that fine, wet sand and "quicksand" are allowed bearing values of from ½ to 2 tons, while coarse sands are allotted much higher values. It has been the experience of the writer in making tests upon the fine, wet sands that they will carry quite as much load as the coarser sands, provided the ground water stands at its normal level.

The chief danger in using such materials for foundation loads lies in the possibility of future excavations being made in the immediate neighborhood, which may be carried to a lower depth than that of the foundations referred to, in which case there may be a flow of surrounding soil toward the new opening, thus undermining the foundation. Such damage, however, will occur whatever may be the unit loading upon the soil.

The writer has never hesitated to recommend loadings as high as 4 tons per sq. ft. upon sand which, during the excavation process, permitted the workmen to sink to their knees in it. Nor has there ever been to his knowledge any observable settlement in such cases.

A distinction is often made between fine sand which is confined and that which is unconfined. The surrounding of a foundation site with tight sheeting is useful in preventing subsequent lateral displacement in the event of adjacent excavations being made, but it does not in the writer's opinion increase the bearing value. If the material is a pure sand it will not flow under pressure alone except under excessive loading. In the case of those sands containing a considerable quantity of clay this may not be true. It is not easily possible to determine how much, if any, clay is contained in a fine sand. The individual grains of sand may, and usually are, so small as to give the mass which they form the general appearance of clay. A microscope may be required in such case to determine accurately whether the particles are of sand or clay. Generally speaking, fine sands containing a considerable quantity of clay will not show the characteristic behavior of quicksand.

Before deciding to utilize fine sand as a foundation for permanent structures, consideration should be given to the future possibility of its becoming saturated under a head which may produce quickness.

The writer recalls a case in which some mill buildings were built upon fine sand on the high bank of a river. Later, a power dam was constructed at a still higher elevation above the mill site, and in the course of time the water impounded behind the dam found its way under the dam and into the fine sand which formed the foundation of the mill buildings. This condition was unknown until the pressure broke through to the

river, undermining one of the buildings and causing its complete collapse. It should be noted, however, that in this, as in all similar failures, the sand under the foundation flowed to a lower level.

Those who have had occasion to drive piles into fine sand have usually found a very decided resistance against penetration in such material. This is but another indication of the natural compactness of fine sand in a quiescent state. If a water jet be resorted to, however, and applied to the soil in advance of the pile tip, it will be found that the pile will sink under the weight of the hammer alone. In other words, a quicksand condition is produced in the sand at the pile point, and the material no longer offers resistance to the load upon it. It is to be recommended, therefore, that in driving either bearing or sheet piles into fine sand, the water jet should be used as an economic aid to facilitate the work.

In connection with the installation of a number of pre-cast concrete piles, some years ago, the writer utilized the jetting process in sinking through a deep bed of fine sand as follows: A long length of ½-in. gas pipe was connected by ordinary garden hose to the city pressure, and a jet sounding was made at each pier location at an expense of ½ cent per lin. ft. Piles were cast of the predetermined length and were jetted down by churning them up and down with an ordinary derrick, a jet pipe having been cast in the center of each pile and connected at the top during driving to a pressure pump. Upon the removal of the jet action, the sand repacked itself around the pile in a condition of maximum density.

A frequent cause of trouble from quicksand has to do with its escape into sewers, drains, or other artificial underground conduits, thus producing voids which must be filled by settlement from above. Any open pipe or conduit laid through wet sand should be constructed with especial care to exclude the surrounding sand. Because of the extreme fineness of many sands this is not easy of accomplishment. When drains are to be laid in such material for the purpose of lowering the ground water level and open joints are left in the pipes to accomplish this result, the joints should not only be wrapped with cloth to exclude the sand but the entire pipe should be surrounded with soft coal cinders which is one of the most useful agents for admitting water while still excluding the passage of sand.

Cinders are also useful during the process of excavating into quicksand for the purpose of maintaining a footing upon which the workmen may stand without sinking into the sand. A frequent liberal sprinkling of this material over the bottom of the trench will be found very effective in preventing miring.

It will also be found in the handling of many quicksands that the ordinary garden fork is more efficient for the purpose than is the type of shovel usually employed. This is due to the fact that fine, wet sand has a very pronounced "suction" which causes the blade of the shovel to stick and requires a greatly increased force to remove it.

In conclusion, then, summarizing the foregoing, it may be said that

quicksand is only a temporary condition of a soil, which ceases to exist after a normal state of ground water has been restored. It is also probably true that many of the troubles encountered from quicksand could often be avoided by the adoption of more scientific methods of handling.

It further is the writer's conviction that the behavior of fine sands under conditions of quickness is in strict accordance with well-recognized physical laws, and not the result of mysterious or unexplainable influences, as is so often readily assumed by many of its victims.

Discussion.

Mr. J. S. Dunwoody.* I should like to ask Colonel Gow if he has had any experience in draining an area of saturated clay with reference to establishing underdrains for foundation work, in regard to the area from which a straight drain would take water.

Colonel Gow. Ordinary clay, unlike sand, does not drain readily. To remove water from clay requires that it be dried out rather than drained. The best method for accomplishing this is to prevent water from coming in contact with the clay stratum and permitting the contained water to evaporate by capillary action.

All plastic clays contain a high water content, and when dried they show a corresponding shrinkage in volume. The moisture in the clay is strongly held in mechanical combination and is released only through the process of surface evaporation.

Obviously, if a series of trenches are excavated in such material the area exposed to surface evaporation is greatly increased and the drying-out process will be considerably accelerated. Unless, however, the trenches are very close to one another their effect as drying agencies will be limited to a very few feet laterally on each side of the trench.

If a given site is surrounded by a relatively deep trench, say 3 to 4 ft. below the surface, having an outlet by which to dispose of accumulated moisture, and if in addition precautions are taken to exclude water from the surface of the site, there will result a drying out of the clay surface to a depth of possibly a foot or more. In case water cannot be absolutely excluded from the site, provision must at least be made for rapid surface drainage to the nearest trench, so as to lead it away before further saturation of the clay results.

* Superintendent Filtration, Erie, Pa.

SOME PRACTICAL SUGGESTIONS TO WATER WORKS OFFICIALS OF BENEFIT TO THE CONSUMER.

DAVID A. HEFFERNAN.*

[*September 10, 1920.*]

Many inquiries are made of water departments relative to different conditions existing in the house service. Although, in many cases, the responsibility of the water works ceases at the meter, it is the opinion of the writer that any information of importance relative to preventing serious damage to the property should be given to the owner by the department.

It is now generally accepted that adequate supervision of plumbing as regards all sanitary fixtures should be vested in the public-health authorities. This will undoubtedly continue to be the general practice except, perhaps, in a few communities where the health department is poorly organized. From the water-works viewpoint no questions of health are involved other than to supply good water.

There are two important reasons, however, which compel the interest of the department in private plumbing. The first is the necessity of preventing undue waste of water; the second is the desirability of promoting general and individual satisfaction and appreciation of the water service.

The best arrangements of piping can be suggested, looking to protection against leakage and frost, accessibility and provision for convenient drainage. The whole broad tendency of modern public service is to extend that service just as far as possible with advantage to the consumer. The consumer should have the benefit of the knowledge and experience of the water-works officials in all ways that will operate to improve his individual service.

It appears to me that it would be advantageous both to the consumer and the water works to institute a campaign of education of the consumer. With this in mind I have set down some of the more ordinary disturbances that are liable to occur in any house plumbing. I have not gone into detail on these matters, but enough to show *my* ideas with the end that they may bring out yours.

1. Installation of service to house.
2. Kind of pipe in supply to house fixtures.
3. Water-closets and their appurtenances.
4. Milky appearance of water.
5. Sweating of cold-water pipes.
6. Water hammer.

* Superintendent Water Works, Milton, Mass.

7. The hot-water system.
   (a) Rumbling in boiler.
   (b) Bursting or collapse of boiler.
   (c) Explosion of water front.
   (d) Dirty hot water.
   (e) Cold water from hot-water fixture, and *vice versa.*
   (f) Air lock.

1. Installation of Service to House.

I believe that the service pipe should be laid by the water department from the main to the meter, regardless of where the meter is set, in manhole or cellar, and that this pipe should be under control of the department. This is the procedure in Milton. The department lays the pipe to the meter, set either in a manhole, inside the property line, or in the cellar, at the cost of the applicant. This pipe is absolutely controlled by the department. Repairs to it are made free of charge in the street and at actual cost inside the line.

The consumer, for his own benefit, should know how to read the meter and take frequent readings. He should keep a clear passage through the cellar to the meter, listen for foreign noises on the piping, denoting leaks, and know how to shut off the water in the cellar in case of need.

From my experience, I prefer a service laid in this manner: Corporation inserted far enough into the main so that it will at least be flush with the inside of the main; gooseneck lead connection rather than a rigid joint; cement-lined wrought-iron pipe with lead-lined couplings for the service pipe; stop and waste cocks of the plug round-way pattern; and meter connected with brass fittings. Where the pressure is in excess of 60 lb., we recommend setting a pressure reducer on the house side of meter to reduce excessive strain on the piping and fixtures; 40 lb. is ample for house supply. Direct pressure should be given the sill-cock supply. Some consumers use a so-called water strainer which is intended to intercept foreign material before it reaches the pressure regulator. The principle is good, but attention is required or they will cause stoppage of the flow by filling up. The main cellar shut-off should, as I have said, be a round-way cock, as, in case of a frozen service, a compressions cock or flat-way cock will present an obstruction preventing the insertion of a thawing tube.

It is also a good plan to install a cock or valve without waste on the house side of the meter, to prevent siphonage in case a pressure boiler is used, and also to prevent water flowing back over the cellar floor when a meter is being changed or repairs being made.

2. Kind of Pipe in Supply to House Fixtures.

The main classes of pipe in use are galvanized iron, brass, lead, wrought iron, steel, and various combinations of these. In the average dwelling-house I think that galvanized pipe is in greatest use, the first reason for its prevalence being its comparatively low cost. Twenty years ago lead was used almost exclusively and with satisfactory results. Common acid will not attack it seriously, it does not rust, and it will permit expansion to a degree without bursting; but like all good old-fashioned things it has been almost wholly discarded of late years, mostly, I believe, because several cases of poisoning were alleged to have been caused by its use.

However, in various communities the different water supplies contain certain impurities. Some waters will act upon the zinc-coated galvanized pipe, producing "zinc salts" and incidentally eating the protective covering. Brass pipe, with all its good qualities, is adversely acted upon by some waters. Hence, it is for each water-works official to *know* the pipe best suited to carry the water supplied to it, and, when called upon, to use that knowledge in recommendation.

3. Water-Closets and Their Appurtenances.

This subject in itself could form the basis for a lengthy talk. There are several types of water-closets; the washout, washdown, siphon, siphon jet, and pneumatic siphon. The type of supply varies, too; the old-style combination valve tank, the siphonic valve tank, the low-down tank and the flushing valve. Any of these supplies and closets may be combined for use.

The washout closet is made with a shallow basin containing water, where the excreta falls. The unsanitary disadvantage lies in the fact that the flush is impeded by the construction of the basin and the soil it contains, thus hindering the ability to carry away the trap contents and diminishing its scouring propensities.

The washdown type of closet permits of stronger flushing and scouring. It also contains less surface which is not covered with water and therefore there is less opportunity for the soil to adhere.

The advantages of the siphon closet are: unimpeded energy of flush, positive siphonage of bowl contents, and less noise. This closet operates in this manner. The closet outlet is in most cases horizontal, and contracted in size, these two factors tending to retard the passage of the water to such an extent that a solid plug or piston of water forms in the outlet arm of the siphon, leaving behind it a vacuum. Atmospheric pressure acting on the surface of the water in the trap, having no pressure to counterbalance it when the vacuum has been formed, at once drives out the contents of the trap, or, in other words, the contents are siphoned. When the contents are drawn down to such a point that air is admitted, the

siphon breaks and the remainder of the flush entering the fixture is sufficient to renew the seal.

In the pneumatic siphon closet there are two traps, one above the other, the lower acting to retard the passage of the water in the same manner as the contracted horizontal outlet in the siphon washdown closet, and thus enabling a vacuum to form.

The siphon jet closet is the same as the siphon washdown, with the difference that impetus is provided by a jet of water discharged directly up the middle arm of the trap, thus filling the long arm of the siphon rapidly.

The lowdown tank acts on the same principles as do the high tanks. The absence of head is overcome by the use of a larger supply from the tank to the closet, by means of which a sufficient supply of water is discharged into the closet to operate the siphon. This type of closet is more accessible, hence easier to repair. It is covered, and thus prevents dust and dirt entering to a great extent. . However, the usual type of tank is flat and fixtures somewhat crowded. It has been my experience that the ball-cock float, being in this crowded condition, will often stick, permitting the water to waste away. If proper fixtures of good material are used inside of the lowdown tank its work will be satisfactory. However, the commonly used rubber valve ball can be improved on. From many inspections we have found that the rubber ball does not always seat perfectly because the supporting wire becomes bent or for other reasons.

The flushing valve is a device patented in several different forms, used in place of a tank for the flushing of water-closets. It is operated by means of a lever or push button, is of the slow-closing type, and before automatically closing will deliver sufficient water to thoroughly flush the closet. It may be operated either under direct or tank pressure, preferably the latter because it does not vary. The advantages gained from the use of the flushing valve are:

It may be used where the use of tank would be difficult.

It is free from noise.

It, and the piping to it, may be easily concealed.

It may be installed to give satisfactory results under high or low, direct or indirect pressure.

From information I have been able to get, the unpopularity of this fixture has arisen from ignorance of plumbers. To work satisfactorily under direct pressure it must be supplied by at least a $1\frac{1}{4}$-in. pipe.

Under tank pressure it is wise not to use a tank of less than 25 gal. capacity, or where a minimum pressure of at least 6 lb. is not available. Pressure in excess of 40 lb., it might be well to add, causes considerable liability of noise and spattering of water.

4. Milky Appearance of Water.

A complaint we are often called upon to explain is the milky appearance water often has. Water absorbs air, either at the source of supply or in passing air chambers or the like. The lower the temperature of the water the more easily it absorbs air, and, of course, as the temperature of the water rises the less power it has to retain the air. Hence water drawn at a high temperature will give off the air it has held in small globules which, when numerous, give the water a milky appearance. Water under high pressure will retain more air than water under no pressure. Therefore the relieving of pressure when water is drawn permits the escape of the air it contained.

5. Sweating of Cold-Water Pipes.

Sweating of pipes occurs when cold pipes pass through a space filled with air which is warmer than the pipes and which contains moisture. The contact of the warm air with the cold surface of the pipe causes the moisture in the warm air to condense on the surface of the pipe. Hot-water pipes never sweat because the surrounding air is cooler than the pipes. This sweating may sometimes be overcome by covering the pipe with five or six windings of paper, with an outer winding of cloth which should be given a coat of heavy paint.

6. Water Hammer.

When water is flowing through a pipe, sudden closing of a valve tends to cause momentarily a high bursting pressure called "water hammer." An extreme pressure would be caused by instantaneous closing. If the pipe is not permitted to move lengthwise, the kinetic energy or momentum of the body of water will exhaust itself in compressing the water and distending the walls of the pipe. In house services this is often caused by self-closing jets. If the piping is weak at any point, the hammer, besides its disagreeable noise, will eventually burst the pipe. A remedy is to install an air-chamber, preferably on the house side of the meter, or to use slow-closing jets. As water is practically non-compressible and air is readily compressed, when the progress of the column of water is retarded suddenly it will strike against the air cushion provided by the chamber, using up the force of the water. To get proper results the air in the chamber should be renewed occasionally.

7. The Hot-Water System.

(a) *Rumbling in Boiler.*

Several causes may contribute to rumbling in the range boiler, among them being the following:

Partial or entire stoppage of boiler supply, house-service pipe, or cold-water pipe on range connection.

Air pocket in water front.

Boiler tube too small.

Range flow pipe sagging or having wrong pitch.

Too great heating surface.

A partial stoppage of supply to the house, boiler, or water front will not permit water to be supplied to the water front as fast as hot water may be drawn from a faucet, and consequently steam may form. If a range flow pipe pitches down to the water front or if the pipe sags, the circulation of hot water from the range is retarded and even stopped momentarily. The water passing through the front becomes overheated, bubbles of steam form, and as these come in contact with the cooler water in the boiler they condense suddenly, producing a partial vacuum which the water at once attempts to fill, thereby causing the rumbling noise.

Water boils at 212° F. at atmospheric pressure. Under 60 lb. pressure it boils at 300°. Hence if water is heated to 210° under this pressure, and the pressure suddenly reduced by opening a fixture, it may be seen that there will be more heat in the water than is necessary to boil it at the reduced pressure, resulting in its instantaneous vaporization and causing the rumbling sound.

This trouble may be overcome by reducing the heating surface, increasing the size of the boiler, the heating of radiation from the boiler or by adding circulation.

(b) *Bursting or Collapse of Boiler.*

Range boilers collapse through the formation of a partial vacuum inside of the boiler and insufficient strength of the shell to withstand the atmospheric pressure. This vacuum is made by siphonage of the boiler. In the case of a pressure boiler conditions are very favorable for this to happen. The boiler tube which extends almost to the bottom of the boiler, forms the short arm of the siphon, while the boiler supply, reaching to the service pipe and street main, represents the long arm.

A siphon will operate by a flow of water to the boiler supply. This may be caused by closing of the stop-and-waste cock which will allow the water to flow through the waste hole, or by a break in the boiler supply pipe, service pipe, or even the street main. When the siphon begins to operate, the contents of the boiler are drained to the bottom of the boiler tube, unless means are taken for its prevention.

It is practically impossible to siphon a boiler supplied by tank pressure because of the fact that the supply comes from above.

There are several ways of preventing boiler siphonage; by drilling a hole in the upper part of the boiler tube, by use of a vacuum valve, or by the use of a check valve in the boiler supply. The idea of a hole in the boiler tube is good, but it is liable to close up with sediment or corrosion.

If it is made too large it will admit cold water into the hot water at the top of the boiler.

The vacuum valve is constructed so that it is held closed by water pressure, but when the pressure is withdrawn, as would be the case when the boiler is being siphoned, atmospheric pressure would open the valve and the air admitted would break the siphon. Its chief drawback, and it is a bad one, is that when it has not been operated for a long time it is apt to become so corroded as to stick and not open under the pressure of the outside air, hence defeating its purpose. The objection to its sticking through infrequent use has been overcome by the Stack safety relief valve which is in reality a combined relief valve and hot-water faucet. This valve may be used on any hot-water system, saves piping, will not stick or leak or cause water hammer. Used in conjunction with a check valve on the house supply it is the safest thing, to my knowledge.

(c) *Explosion of Water Front.*

If, on a direct pressure boiler, stoppage is caused in the boiler supply, all means of expansion are cut off and the confined pressure produces an explosion at the weakest point, generally the water front. A check valve on the boiler supply without the use of a relief valve, closing of the supply valve without opening a faucet to relieve the pressure, will act in the same manner if the range contains fire. This condition often exists in cold weather, when the service pipe or boiler supply freezes. Bursting of the water front cannot take place under tank pressure because of the expansion pipe.

(d) *Dirty Hot Water.*

Hot water is often made dirty by its contact with a cast-iron water front. Hard water will not act in this manner. Use of a brass water front will eliminate this trouble, or, in the case of an iron front, if a little milk of lime is kept in the water until a protective coating is formed it will be found to be a remedy. Galvanized piping in the hot-water system or sediment drawn from the boiler is another cause.

If the boiler is supplied from an uncovered tank in the attic, neglect of cleaning the tank will contribute its share of supplying dirty water. A galvanized-iron boiler is another frequent cause.

(e) *Cold Water from Hot-Water Fixture, and Vice Versa.*

It often happens when water in the boiler is overheated that it will cause the hot water to back into the cold-water piping. When the water is heated to this extent, the upper part of the boiler fills with steam, the expansion of which drives the hot water into the cold-water pipes.

When cold water is drawn from a hot-water faucet it may be due to the boiler tube having rusted off or been omitted, or to the fact that the

siphon hole is too large. Any of these three causes may result in the top of the boiler filling with cold water, permitting it to enter the flow pipe from the boiler.

(f) *Air Lock.*

Air lock is caused by the collection of air at high points on the system of hot-water piping when such points are not vented. The air was in the water when it entered the water front, where it was liberated by the heat. This condition occurs only in systems under low pressure. If the water pressure is strong enough, the air will be forced out as fast as it attempts to accumulate. An expansion pipe run from the high point on the piping, and carried to the supply tank will prevent the accumulation of air.

I have touched concisely on some of the more frequent questions which a water-works official is liable to encounter, and, while I realize that knowledge of these and kindred topics is not obligatory, still I feel that it is necessary that we be able to answer them in order to maintain our self-respect, if not our positions.

DISCUSSION.

MR. HEFFERNAN. In talking about low-down tanks, there are a number of types of valves used very commonly. There is the rubber float valve which is commonly used, but there is considerable water wasted down through the flush pipe, and I really think the manufacturers' attention ought to be drawn to the fact, to discourage the sale of these, because it is a burden to the consumer on account of the water which goes to waste by the use of the rubber valves.

MR. GEORGE H. KING.* I should like to ask Mr. Heffernan if he said that the "Stack" faucet would act as both a vacuum and pressure relief valve.

MR. HEFFERNAN. No, only as a relief valve.

PRESIDENT MACKSEY. I should like to ask what he recommends in place of the rubber float valve.

MR. HEFFERNAN. If I had my way, I would go back to the old valve. I would not use a siphon valve. You remember the old chain installation, where as soon as you let go of it the water stops! The wire that is connected with this valve, on the flush pipe, is such a delicate thing that the suction of water in filling the tank bends the wire and the valve does not seat properly. I think it is too light for the purpose, where a heavier bronze or brass valve would be the proper thing to use.

MR. A. R. HATHAWAY.† These valves being made of rubber, they will swell. You know the wire which supports them runs up through a ring, and when they swell they do not seat properly, which allows a stream of water to run down. We have some on exhibition to show the leakage that these afford. I have seen widely advertised a new type of non-

* Superintendent Water Works, Taunton, Mass.

† Water Registrar, Springfield, Mass.

swelling valve, which avoids all danger of swelling. It has sometimes been an interesting question in explaining to consumers a large bill.

Mr. George H. Finneran.* Is there any law relating to boiler collapses? Don't the city have to settle any claim?

Mr. Heffernan. No, this is the only case where we settled.

Mr. Finneran. Have you anything regarding it incorporated in your rules and regulations?

Mr. Heffernan. Yes, every consumer signs this condition, and it is all embodied in it.

Mr. F. L. Cushing.† I might add that the city of Medford has provided for that, having experienced several collapses, and put it upon the plumbing inspector by city ordinance to see that every house connected with a pressure boiler has a vacuum valve. The plumbing inspector's rules already had provisions for relief valve for pressure, and we charge the owners with the expense if they blow hot water through the meter. So, we don't have any check valves and do not see any need of the check valve, but we do require vacuum or relief valves.

Chairman Sherman. Don't you find it necessary to charge them for new disks fairly frequently?

Mr. Cushing. No, we haven't had many occasions where they blew the hot water through. We had some steam plants where they did, but not from a house stove.

Mr. E. D. Eldridge.‡ In our town I took the stand that it is for the interest of the water works to see that the consumers get the best possible service. Our town is not so large but what I am familiar with all the installations, and I willingly give advice, and in course of time people have come to regard it with confidence and appreciate and adopt my suggestions. We do not have difference enough in levels to make boiler collapse a serious item. I never knew but one case where it happened, and I think that was because it was unduly weak. I never had any confidence in a vacuum valve. They are likely to stick to the seat. The area is so small that a slight resistance would prevent the entrance of air, even against a perfect vacuum. We are without meters, so that the boiler expansion takes place back into the main, but in a few cases — where the fire is run hard things may happen that are unexpected — we have recommended and put on the Stack faucet. That permits the relief of pressure in case any excess should occur.

This case of rubber ball valves is a very frequent cause of trouble. Very often the balls expand so that they do not come down properly on the seat.

The question of piping is quite an important one. A great many people do not regard the qualities of pipe, and think more of the cost of

* Superintendent Water Service, Boston, Mass.
† Water Registrar, Medford, Mass.
‡ Superintendent Water Company, Onset, Mass.

installations. Therefore, some classes of galvanized boilers cause rust, and we find pin holes come through the boilers. We always recommend the use of a copper boiler, and usually our advice is heeded. In the case of a galvanized boiler, we always fear a vent hole in the top of the tap becoming corroded, as the speaker has said, and sometimes drill out that hole and put in a brass bushing, with the idea that it would not corrode as readily. The expansion is due perhaps to the formation of steam, and also to the direct expansion from cold to hot, and whenever anything unusual occurs in the house, or the water is shut off, or the tenant is not familiar with it, we try to impress on him the importance of opening hot-water taps, and that does away with any danger of vacuum or pressure.

The expansion back from the boiler into the pipe should be noted, particularly if the cold-water supply is through a galvanized-iron pipe. Cases have occurred where the galvanized-iron pipe has become stopped close to the boiler by the expansion of water back into the boiler, the hot water having the more corrosive action than the cold. We recommend that the pipe in the cold-water system eight or ten feet away from the boiler should be brass. There is sometimes a defect in brass piping, particularly in the tubing, which has practically gone out of use now. Sometimes it will happen that little drops of water will appear on the surface of piping, which will usually evaporate about as fast as it leaks. On a damp day, or if the water is a little cold, it will leak. That is a trouble that is inherent in the manufacture of pipe, and is a defect of the pipe. There is very little trouble in the iron pipe.

EPIDEMIC OF GASTRO-ENTERITIS IN PEABODY, MASS., OCTOBER, 1913.

ARTHUR D. WESTON.*

[*Read September 8, 1920.*]

The town of Peabody is supplied with water from three sources, viz., Spring Pond, Brown's Pond, and Suntaug Lake. With Suntaug Lake this paper is not concerned, since the water was not used at the time of the epidemic herein described.

The water of Spring Pond flows through a channel-like basin for a distance of 2 500 ft. to two small basins, and near the lower of these basins the pumping station is located. At the lower basin the water is taken into the pump well in the pumping station, from which it is pumped into the distributing system. The water from Brown's Pond may flow through a 24-in. vitrified pipe to Spring Pond, or through a 12-in. cast-iron pipe to the upper basin. Spring Pond has an area of 63.6 acres and a drainage area of 0.39 square mile, the soil of which is largely porous. At the time of the epidemic in question, there were numerous sources of possible pollution at the extreme upper end of this pond, located, however, at a considerable distance from the shore. Large icehouses are situated at two points on the westerly side near the shore of the pond, from which ice was hauled to Peabody during much of the year, but there are no other buildings on the shores of the pond.

The watershed of Brown's Pond contains considerable population, but as the only method of drawing water from this pond is through the pipes already mentioned, and as the gates on the pipes were closed, there was no evidence to connect Brown's Pond with the epidemic in any way.

The epidemic was reported to the State Board of Health by the Board of Health of Peabody on the morning of Saturday, October 4, and was described as being exceedingly explosive in character, nearly all of the cases having begun with severe diarrhea at about four o'clock in the morning of the 4th. As nearly as could be computed, at least 1 500 cases occurred in the town, with the probability that even a far greater number of persons was affected. The population of the town at this time was about 18 600.

Bacteria samples were obtained from the sources of water supply on the morning of October 4, not more than six or eight hours after the epidemic began, and a series of samples was taken from taps throughout the town. All of these samples collected on the first day showed a total bacterial count somewhat higher than usual, with *B. coli* present in 10

* Principal Assistant Engineer, Mass. State Department of Health.

c.c. in about 30 per cent. of the samples, and in 1.0 c.c. in about 17 per cent. of the samples. No *B. coli* were found in quantities smaller than 1.0 c.c., but a fermentative bacterium, reddish in color, was noted in all the samples in 1.0 c.c., and in about 30 per cent. of the samples in .10 c.c.

Another series of samples was collected two days later, on October 6, and in these samples the red bacterium was noted in all samples from the sources and taps in the town, but only in 10 c.c., while *B. coli* were found in but one sample, that from the lower basins, in quantities smaller than 10 c.c., both *B. coli* and the red bacterium being found in this sample in 1 c.c.

Inspections and careful investigations were immediately made on October 4 of the basins and the channel above them and of the watershed of Spring Pond, with the result that numerous deposits of fecal matter were discovered on the edges of the lower basin near the pumping station, at points in the neighborhood of the upper basins and at points along Spring Pond all the way to its upper end, a considerable deposit being found near the ice house at the upper end of the pond. Inquiry showed that several persons had fished from the shores on the day previous to the epidemic, and, in fact, fishermen were present on the shores when the investigation began.

It was discovered by the physicians that the infection which caused the epidemic probably occurred within a few hours before the explosion on the morning of October 4. On the evening of October 2 there was a sharp shower, in which there was a rainfall of 0.23 of an inch, which may have aided materially in washing the infective matter into the reservoir, since in some cases it lay on the sloping banks of the basins adjacent to the pumping station and on the edge of the water in Spring Pond. There was also rain amounting to 0.32 of an inch on the previous day, October 1, but this rainfall was spread over a longer period.

The disease was characterized by an extremely abrupt onset, with vomiting, diarrhea, and some instances of considerable prostration, sufficient, in many cases, to cause alarm. While some of the cases were very serious and recovery did not take place for several days, no deaths resulted and no further disturbance from this cause was noted.

When results of the investigations indicated the probability that the water supply was the cause of the epidemic, Spring Pond and the basins below the pond were at once shut off, the mains and distributing reservoir were flushed out, and water taken from Suntaug Lake.

As a result of this epidemic the State Board of Health recommended that, after the removal of the deposits of excrement about the Spring Pond basins and the distributing reservoir, fishing in the ponds and basins be prevented and the rules and regulations established for the sanitary protection of this water supply be strictly enforced. It is interesting to note that appeals for the privilege of fishing are still made, notwithstanding the lesson taught by this epidemic.

FURTHER TESTS OF THE UNAFLOW PUMPING ENGINE.

BY D. A. DECROW, OF THE WORTHINGTON PUMP AND MACHINERY CORPORATION, NEW YORK.

[*Read September 8, 1920.*]

The Unaflow pumping engine tested, the first of its type, was designed primarily for experimental purposes, with a view of determining —

1. The permissible speeds for reciprocating pumping engines of this type.
2. The steam consumption of the Unaflow engine operated at permissible reciprocating engine speeds.
3. Its efficiency when operating at these speeds.
4. Its duty or useful work per 1 000 lb. of steam under various operating conditions.

With these objects in mind it was decided to design, construct, operate, and test a single-cylinder horizontal crank and flywheel Unaflow pumping unit of the extended type, having a nominal capacity of 2½ to 3 million U. S. gallons per twenty-four hours.

The commissioner of public works of the city of Buffalo, upon request, gave permission for the installation of such a unit in the Porter Avenue Water Works Pumping Station of that city.

This pumping engine has a steam cylinder 13½-in. diameter by 21-in. stroke, directly connected at its outboard end, through an extension of its piston rod, to one double-acting pump having a plunger 9 in. diameter by 21 in. stroke, though the pump was so designed that plungers up to 11 in. could be installed if desired for experimental purposes. With the 9 in. diameter plunger, and operating at a speed of 210 revolutions per minute, its nominal capacity is 3 million U. S. gallons per day. When completed and installed, the pump suction was connected by a suction pipe about 60 ft. long to the same pump well or conduit that supplies the other pumping engines in the Porter Avenue Station, the suction lift being approximately 15 ft.

The water pumped was discharged back into this well through a pipe provided for that purpose, and any desired water pressure was maintained by throttling a gate valve in this discharge main.

For convenience in testing, a surface condenser in the discharge line and an independent air pump were used.

Some thirty-five or forty tests of various kinds were made, in trying out the various features of the installation, some of them rather unusual; for instance, operating a single plunger pump at 735-ft. piston speed per minute.

During these tests the station steam pressure only was available. This varied from time to time from 200 to 225 lb. gage, superheated some 10° to 20° F. at the engine. After a part of the tests had been made, an independently oil-fired Foster Superheater was connected to the steam line and different steam temperatures were thereafter readily obtained.

Before the tests were commenced, all instruments and the weighing apparatus were carefully calibrated.

On account of the size of the unit and facilities for testing, a uniform period of two hours was adopted for each test, and with few exceptions all of them extended over this period. The steam for operating the independent air pump was not charged against the engine.

The engine frame was the enclosed type; the mechanical lubrication was flow and splash; the cylinder lubrication was positive, and introduced into the cylinder at the top about one third of each stroke from the cylinder head end. There have been no lubrication troubles of any nature, either in the bearings, running parts, or steam cylinder. A thorough examination, after the engine had been in service for some time, showed the main and other bearings to be in first-class condition, with no appreciable signs of wear. There have been no hot bearings during the operating life of this engine. The machine oil used was the oil ordinarily used at the Porter Avenue Pumping Station on the slow-running, 30-million gal. vertical triplex expansion pumping engines in that station. The examination of the steam cylinder and piston showed them to be in excellent condition, the running surfaces well glazed over and polished, with no indication of abrasion, either on the surface of piston or in the cylinder at the exhaust ports.

The general principle of the Unaflow Steam Engine, from which it derives its name, is that the steam flows in one direction through the steam cylinder; ordinarily being admitted through the heated head at each end and exhausted at a point most distant from the point of admission. There is no reversal of steam over its own path, high compression is obtained and initial condensation is practically eliminated even with short cut-off, with the result that high economies are developed in a single cylinder engine of this type.

As in a previous paper read before this Association, the Unaflow Pumping Engine was quite fully illustrated, no illustrations accompany this one.

Below are given condensed tabulations of twenty-four different tests:

Summary of Results of Three Tests Made on March 23 and 24, 1920.

These three tests were made particularly for the purpose of ascertaining the per cent. of slip and the relative duties, when operating with normal M.E.P. in the steam cylinder, with one third overload, and with two thirds overload. The overload conditions were obtained by throttling

the discharge gate valve and increasing the discharge pressures, all other conditions, such as speed, steam pressure, vacuum and so forth, remaining as nearly constant as possible. The diameter of the pump plunger was 11 in. and the diameter of the pump plunger rod was 3 in. The useful-water horsepower was approximately 90 per cent. of the steam-indicated horsepower in each case.

The duty stated is the duty in million foot-pounds per 1 000 lb. of steam, and is calculated from plunger displacement.

It is, perhaps, unnecessary to call attention to the fact that the unit is comparatively small and that considerably better results may be anticipated from larger ones.

	Date of Trials.		
	March 23, 1920.	March 24, 1920.	March 24, 1920.
Steam pressure at throttle, pounds gage	220.	218.	222.
Steam temperature at throttle, degrees F.	562.4	562.5	569.
Superheat at throttle, degrees F.	167.	167.7	173.
Vacuum, inches mercury	27.	27.5	27.3
Total head, feet	153.	195.6	251.7
Revolutions per minute	150.7	149.6	152.
Duty, million foot-pounds	146.1	147.2	150.1
Average M.E.P. (pounds)	48.5	61.4	78.3
Indicated H.P.	103.	132.	171.
Steam per I.H.P. hour (pounds)	12.2	12.1	11.9
Gallons per minute pumped (p. d.)	2 410.	2 390.	2 430.
Gallons per minute pumped (cal. noz.)	2 370.	2 340.	2 360.
Slip (per cent.)	1.7	2.1	2.9
Average velocity through pump valves*	3.4	3.4	3.5
Duty, average of three tests, million foot-pounds	....	....	147.8
Slip, average of three tests, per cent.	....	....	2.2

* Feet per second.

It will be noted that there was an apparent slight increase in duty as the mean effective pressure in the steam cylinder was increased, but the results, being so nearly alike, indicate a very flat economy curve.

For the purpose of checking the relative steam consumption and duties at different mean effective pressures in the steam cylinder, another series of tests was made during which the steam pressures were lower, the amount of superheat much less, and the vacuum in the condenser somewhat lower due partly to barometric conditions, for the barometer readings averaged 29.3 in.

An 8-in. plunger had been substituted for the 11-in. plunger, and considerably higher water pressure in the pump was maintained.

A summary of these tests is given on page 198.

During these three tests the operating conditions were maintained as nearly uniform as practical, except the mean effective pressures in the steam cylinder were changed by increasing the discharge pressures in the pump.

The duties obtained confirm the results of the previous tests in that they show a slightly better economy for the higher mean-effective pressure

	Date of Trials.		
	August 25.	August 25.	August 28.
Steam pressure at throttle, pounds gage	205.	209.	216.
Steam temperature at throttle, degrees F.	426.	428.	430.
Superheat at throttle, degrees F.	36.	36.	36.
Vacuum, inches mercury	26.5	26.3	25.8
Total head, feet	249.5	302.5	366.7
Revolutions per minute	210.	207.5	208.
Duty million foot-pounds	128.3	131.5	132.
Average M.E.P. pounds	39.3	46.	57.8
Indicated H.P.	118.8	137.8	173.5
Steam per I.H.P. hour (pounds)	13.6	13.5	13.3
Efficiency, per cent.	88.	90.	87.2
Capacity per minute (plunger dis.)	1 646.	1 630.	1 633.

in the steam cylinder, but again the difference is so slight that it confirms the flat economy curve characteristics of this type of steam prime mover.

No proper calibrated nozzles were available for measuring the water pumped during these tests, so no acceptable slip tests could be made.

In November and December last, a number of tests were made, and the results of eighteen of them are tabulated below:

No.	R.P.M.*	Steam.†	Sup'h't.‡	T.W.P.¶	Duty.
1	98.6	217.	0	96.3	101.5
2	124.3	218.7	7.	96.2	109.
3	149.7	216.7	9.	97.	115.7
4	177.3	215.3	25.	97.7	126.3
5	201.1	213.	22.	97.5	132.0
6	102.	219.	55.	96.	132.5
7	125.8	216.	53.	98.8	135.5
8	150.1	217.	50.	97.2	133.4
9	177.	216.	52.4	98.	138.5
10	200.2	215.	58.	97.	144.0
11	173.6	214.	94.1	95.2	153.6
12	199.6	215.	89.4	99.	157.
13	99.	216.	17.	116.	110.
14	122.6	214.	20.7	115.	120.4
15	148.6	210.	27.4	120.	127.5
16	176.4	210.	30.	120.	131.
17	199.3	212.	31.	123.	134.
18	198.4	224.	39.	97.5	91.

* R.P.M. — Revolutions per minute.
† Steam — Steam pressure by gage.
‡ Sup'h't — Superheat in degrees F.
¶ T.W.P. — Total water pressure.

NOTE. — Pump plunger diameter, 9 in. During the last test the engine exhausted against atmospheric pressure, i.e., high pressure; non-condensing. Test No. 12 gave a steam consumption of 11.4 lb. per 1 H.P. hour.

At all times during its operation the engine was under the control of its variable speed governor.

The results of all of these tests indicate that the permissible speeds of this type of pumping engine are much higher than considered advisable for familiar types of crank and flywheel pumping engines; the results as

to steam economy speak for themselves, they indicate higher economy for higher speeds and temperatures.

For the purpose of demonstrating the action of a single plunger operating at the speeds contemplated, this pumping unit was made with one steam cylinder and one double-acting plunger pump, but in ordinary practice the Unaflow pumping engine will be made with two double-acting plunger pumps and two steam cylinders, cranks set at "quarters" or 90 degrees apart; or it may be made triplex, with the cranks set at 120 degrees.

Discussion.

Mr. William W. Brush.* Is there any practical limit to be placed on the size of this engine?

Mr. Decrow. No other limit than there would be in any type of a horizontal engine. It does not lend itself quite so well to a vertical engine, because the moving parts become much heavier.

Mr. A. O. Doane.† Have you ever considered reducing the size of this steam end in very fast running? This pump runs very fast, but the question is, if some makers have orders for a Unaflow and run the engine very fast, and thus reduce the size and weight and by the use of gears make any desired pump speed.

Mr. Decrow. The speed at which we ran this engine was practically the speeds recommended by the Unaflow people as the proper engine speeds. Our experiments were to determine whether it was practical to run the engine at the same speeds as was practical under practice. For instance, this engine is rated at two hundred and ten revolutions per minute. We guarantee it to settle down to two hundred and seventy-five revolutions per minute, but it is going to be a better unit direct-connected to a pump. This water end does not move any faster than in a slow-moving engine. We will say it has a capacity of three million gallons. The proper speed is only three feet per second. At that speed it would result in a larger water end.

Mr. Brush. Is the pumping engine one that you consider more available?

Mr. Decrow. We consider the Unaflow engine commercially available. This particular unit is put up for experimental purposes to determine whether one cylinder and one plunger could run at those speeds. We can build double machines, and it would then be much more easy in operation. We would expect to put it out double, and the sales we have made at the present time are sales of double engines.

Mr. Brush. Some of those engines have been sold?

Mr. Decrow. Yes. They are not in operation, but they have been put together.

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* Deputy Chief Engineer, Bureau of Water Supply, New York.

† Division Engineer, Metropolitan Water Works.

EXPLOSION OF HOT-WATER BOILER IN BELMONT, MASS.

EDW. J. LOONEY.*

[*September 10, 1920.*]

A hot-water boiler in lower flat of house owned by Miss J. D. Swasey, at the corner of Goden and School streets, and occupied by Mr. Walter A. Putnam, exploded about 2.30 A.M. on the 28th of April, 1920, and made a wreck of the back part of the house.

It is stated that a member of Mr. Putnam's family started the fire in a Stack heater about midnight, and did not turn the fire out. As there was no relief valve on pressure boiler, and the check valve on cold-water line prevented water backing into main pipe, the boiler had to give way.

The town of Belmont water department requires a check valve applied to all pressure boilers, and every water taker has received a copy of the town by-laws relative to the water department rules and regulations.

"*Rule 5.* — A check valve must be applied to all pressure boilers."

One reason for using a check valve is that it will protect the boiler in case water is shut off for extensions or repairs. In a frozen dead end, it will prevent houses on different elevations from being siphoned. The principal reason is to prevent the hot water from backing through meter chamber and spoiling the disk.

On the 28th of April, 1920, the chief of police telephoned at noon that he wanted the pressure read at this house. We went down and found pressure in cellar 86 lb. A member of the state police met us and rode to the water department shop to read the Metropolitan Water Works register, as he wished to see if there would be any indication of disturbance at the hour of explosion. There is now talk of an action for damages, and on the 21st of July, 1920, at the request of Miss J. D. Swasey or Mr. W. A. Putnam, we turned water off at curb, to have meter setting and check valve examined.

At the request of the Belmont water commissioners we sent a questionnaire to the water departments in the Metropolitan District, to discover the practice as followed elsewhere in using check valves on boilers supplied direct from the main pipe.

The answers received show that 40 per cent. of the departments use check valves on pressure boilers.

Discussion.

President Macksey. I happened to run across the case that Mr. Looney speaks of, being acquainted with the tenant in whose apartment the boiler was situated.

* Superintendent Water Works, Belmont, Mass.

It appears that a young man late at night turned the gas on and had a hot bath. He said that he turned the gas off and went to bed. It is true that he went to bed, but he did not shut off the gas. About one or two o'clock the boiler blew up. The service had been divided at the cellar wall to cover two apartments, with a separate meter on each branch, each branch check valved. There was no relief valve on the system. The present owner had owned the house but a few years. She probably knew nothing about the meters or check valves, and they were in place when she took possession. She felt that her property had been destroyed, due to the carelessness of the tenant, and contemplated suit. I advised the tenant to get started early and sue her, because he had a perfect right to suppose that he might with safety heat water in his boiler and let it boil. "But," he said, "what's the use? The owner probably has an equity in this property, and that is about all she has in the world." I advised that he "join the town with the owner in the suit, for, while the town is no doubt justified in installing a meter, it is not justified in making conditions which will be unsafe, without notifying the owners. Judging from my own experience, the foreman usually tells the occupants that he has put on a check valve and that they should protect themselves; there is usually no written record.

The house has been repaired, and the tenants still are there. I am quite sure that they paid no damages, and I doubt if the owner paid them anything. I suppose that if the town had paid anything it would appear in Mr. Looney's paper.

What should be done in a case of this kind? There are many good reasons for checking the back-flow of water after it has passed into these hot-water heaters, and yet we knew that with frequent change in ownership and the ignorance and carelessness of caretakers and janitors, lives and property are endangered. What should we do? It may be that there is a valve which can be put on which will relieve pressure. If it relieves pressure once, it will never righten up again. There is a faucet that will relieve pressure, which I think is reliable. It is not widely known, and it is not generally used. It is possible to provide for the conditions existing, but who is going to guarantee the permanence of those conditions? One would think — naturally the layman would say, — "The plumbing inspector looks after that." But the plumbing inspector does nothing of the kind. The plumbing inspector's authority extends only as far as sewage and drainage are concerned. He doesn't inspect the water supply.

I believe that the real remedy is this: the duty and authority of the plumbing inspector should be extended so that he will inspect water supply pipes and fixtures; and that the water department should not only be authorized, but should be commanded not to supply water where the fixtures were such that the lives and property of the inmates would be imperiled.

Mr. Heffernan. In the town of Milton, in 1916, I went before the committee on revision in regard to the building and plumbing laws of the town, took up this question of relief valves, vacuum, etc., on pressure boilers and had the following by-law adopted. (See Section 16 of paper read by Mr. Heffernan.)

I might say that, in regard to a number of patented valves on the market, you cannot depend upon anything that works automatically. We had a case on a 6-in. line. It was at the high elevation, and a break occurred on the main line at a low point. When the water was turned on we had to open a $2\frac{1}{2}$-in. connection to allow the air to escape. It puzzled me and also the inspector. There was a pressure boiler on the high elevation, and by the opening of the $2\frac{1}{2}$-in. connection the boiler siphoned out. There was a vacuum valve on the system. The boiler collapsed, and we paid over five hundred dollars for a new boiler.

Now, I took that matter up with the inspector of plumbing carefully. The tank valve stuck and did not work. Our conditions of supplying water are intended to protect us from damages caused by shutting off the water.

Mr. Alfred R. Hathaway. In Springfield we have a modern building law. I am sure I have seen in the regulations a requirement that every hot-water installation shall have a relief valve properly placed, of such pattern as may be approved by the building commissioners. If any one will write the building commissioners at Springfield, he might learn something of interest.

President Macksey. It is named the "Stack" valve, and is sold by a man at Portland.

A STUDY OF MASSACHUSETTS WATER SUPPLIES AND THE TYPHOID RATE.

Innocence or Repentance in Drinking Waters.

BY H. W. CLARK.*

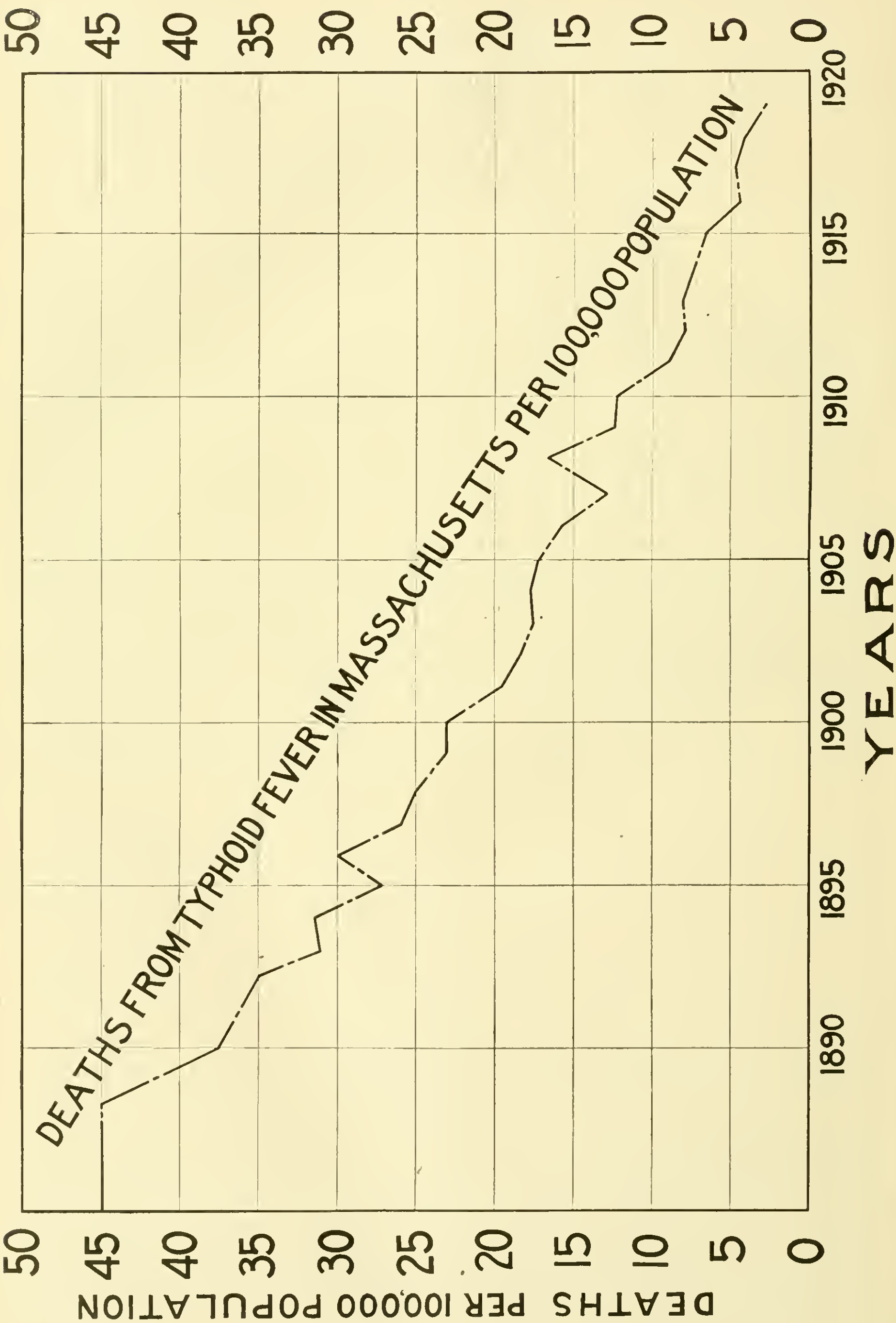
[*Read at N. E. Water Works Asso. Convention, Holyoke, Mass., September, 1920.*]

Thirty-five years ago the late Dr. Thomas M. Drown, at that time chemist to the State Board of Health of Massachusetts and also chief of the Department of Chemistry at the Massachusetts Institute of Technology, stated in one of his early papers on the subject of water that a pure water was to be preferred to an impure water purified; or, in other words, as he expressed it, innocence was better than repentance in water supplies.

The chemist, the bacteriologist, and the engineer may know and prove that the effluent from a filter which has received polluted water but which has been efficiently managed is, in every respect that can be determined by tests, fully equal to another water which has never been polluted; yet on the whole the general consumer would undoubtedly prefer the innocent to what Dr. Drown called the "repentant" water. This expression of Dr. Drown's was assigned to me as the title of this brief paper, and I have accepted it although not responsible for it, the responsibility lying with the chairman of your program committee, Mr. Sherman. Let us, however, make a brief study of Massachusetts water supplies in connection with the water-borne disease, typhoid fever.

During the past thirty-five years the typhoid-fever death rate of Massachusetts has decreased, as shown by the diagram, from 45 per 100 000 inhabitants in the state to less than 3 per 100 000 inhabitants; or, to be exact, to 2.6 — the lowest in the country and as low as in England and Wales or the standard rate which we have been striving for for many years. During the same period — namely, thirty-five years — public water supplies in the state have increased in number from 110 to 213, and the percentage of population using these supplies from about 78 to 96. Furthermore, during this period many poor supplies have been abandoned, better supplies, including the metropolitan system, introduced, and more systematic and thorough guardianship of watersheds exercised. Undoubtedly the largest factor in the tremendous decrease in the typhoid death rate of the state has been the introduction and improvement of these public-water supplies and the doing away with the use of contaminated well waters. With the introduction of public water supplies, moreover, sewerage systems have been installed through the state in all the cities and practically all the large towns, and with these two modern conven-

* Chief Chemist, Mass. Department of Public Health.


DEATHS FROM TYPHOID FEVER IN MASSACHUSETTS PER 100,000 POPULATION
DEATHS PER 100,000 POPULATION
YEARS
1890
1895
1900
1905
1910
1915
1920
0
5
10
15
20
25
30
35
40
45
50

iences, namely, an ample supply of good water and a suitable means of discharging the waste water from the premises of every household, has been the introduction of, first, water-closets doing away with privy vaults and other like contrivances, and the introduction of flowing water and the bathtub, hence greater personal cleanliness of the average family. The old methods of caring for the sewage of a family not only continually polluted the domestic well waters in use, but caused the breeding of innumerable flies, and these flies also spread disease by contaminating milk and other food. In some portions of the country the construction of sewerage systems caused the discharge of much sewage into rivers also used as water supplies, hence an increase in the typhoid rate; but in Massachusetts the direct discharge of the sewage of a municipality into a river used afterwards as a water supply only occurs in one instance, namely, the Merrimack and its tributaries above Lawrence. Furthermore, greater watchfulness of state and municipalities over milk supplies and food in general has also been scientifically developed during the same period; that is, there was begun about thirty-five years ago a circle of reforms in sanitation, each reacting favorably upon the other, and these reforms have greatly influenced the health and well-being of every community.

Typhoid-fever epidemics due to the use of polluted water, contaminated milk, and other causes have diminished rapidly, until to-day the Division of Communicable Diseases of the Massachusetts Department of Public Health considers that practically all typhoid occurring in the state is due to the fact that the state always contains certain typhoid carriers, so called, — that is, persons never free from this disease, — and these carriers, owing to more or less personal contact, prevent the complete elimination of typhoid in the Commonwealth. All health authorities agree, however, that a pure water supply is the chief factor in controlling typhoid, and a polluted water-supply furnishes the greatest danger of a serious and widespread epidemic.

During the past twenty-five or thirty years two important methods of purifying water — and by this means rendering unsafe supplies safe or unsatisfactory supplies satisfactory — have been quite fully developed; namely, municipal filtration and the use of chloride of lime or liquid chlorine. Studies of filtration were begun by the Massachusetts State Board of Health at Lawrence nearly thirty-five years ago. The first result of these studies was the construction of the Lawrence filter, and this started the work throughout the country upon the scientific purification of public water supplies by filtration. No one has a firmer belief in the value of filtration than the speaker, and no one has urged filter installation stronger than he, wherever a water supply needs such purification. The lesser but still great value of hypochlorite or liquid chlorine has also been too well established to need much discussion here. I have had some disappointing experiences with it, especially in cold weather, however; and I believe others have also had like experiences, judging from reports in

health and water-works journals. It is apparently sometimes irregular in its action, but, undoubtedly, methods for its application will be much improved as time goes on. As efficient as chlorine treatment is, to my mind it is not really in the same class as a purification measure with adequate filtration. It is at times, however, a valuable adjunct to filtration and an efficient means of cutting down the bacterial contents of certain unfiltered supplies suspected or known to be unsatisfactory and unsafe. The supplies that have come under my own observation, however, which need chlorine treatment, generally need filtration; and the use of chlorine, in Massachusetts at least, should perhaps only be resorted to as a temporary measure, or where the expense of obtaining a new supply or filtering the old supply is practically prohibitive. It is, of course, also a most excellent finishing process following filtration.

Throughout large sections of the country, especially where polluted river waters have to be used as municipal water supplies, filters or chlorine treatment, or both, are absolutely necessary; and that filtration is an efficient method of eliminating water-borne typhoid, an enormous amount of reliable data collected during the past twenty-five years has absolutely proved. To be successful, filters must be of suitable construction, adapted to the water which they are filtering, and operated under good supervision; in other words, they must be designed by experts and operated under expert supervision. We all know there are many filters scattered throughout the country not so designed or operated.

At the present time I understand that approximately 22 million people in the country are using filtered water, and that liquid chlorine or hypochlorite installations have been made in upward of 2 500 cities and towns. Massachusetts is a state, however, with very few filters in operation and few chlorine plants; yet, as I stated in the beginning, it has the lowest typhoid-fever death rate of any state in the country. Of the 3 700 000 people, more or less, within its borders using or having access to public water supplies, about 450 000, or not over 12 per cent., use filtered water. Lawrence, Lowell, Newburyport, and Springfield are the only cities, and Brookline the only large town, filtering their supply. Of course there are other filters, as at Middleborough, Reading, Cohasset, Norwood, etc., but the actual population supplied in the state in this way is comparatively small. Moreover, of the four large municipalities which I have mentioned as filtering their supply, only one, Lawrence, does so on account of bacterial pollution; Springfield filters largely to improve its water physically, and Lowell and Brookline to remove manganese and iron, as do a number of the smaller towns in the state. So far as I am aware, moreover, only seven municipalities in the state have chlorine plants in operation all or part of the time, and one of these is Lawrence, which first filters its supply.

The Lawrence filters and what they have accomplished have been too often discussed to need description here. They have a heavy burden to bear, as they receive perhaps the most polluted water applied to any

filters in the country, and the low typhoid rate at Lawrence speaks well for their efficiency. Last year the typhoid rate at Lawrence was 8.6 per 100 000 inhabitants. This rate is considerably higher than the average for the state, but compares well with many cities and towns throughout the country using absolutely unpolluted supplies. In a paper by Col. George A. Johnson, read a few years ago before the American Water Works Association, and entitled " The Typhoid Toll," was a statement that " purification of all supplies in the northern part of the United States would result in the reduction of the annual typhoid death rate to a figure usually less than 20 per 100 000 " ; and this statement, ascribed to Dr. Allen Freeman, is agreed to by Colonel Johnson. Moreover, as long ago as 1902, Sedgwick and Winslow in a paper before the American Public Health Association stated " that in urban communities supplied with pure water there still remains a typhoid fever tax of from 15 to 25 deaths per 100 000 population yearly." They also stated, " This tax is not due to any peculiar condition of soil, locality, climate or endemic factors but to incomplete disinfection of typhoid excreta, with subsequent infection of food and drink."

The policy of Massachusetts thirty-five years ago and now — and it is of course the policy of the whole country where it can be followed — is to obtain a water supply, for every city and town, that is safe; that is, a supply that can be used for all domestic purposes without any purification treatment other than storage. The state has been almost phenomenally successful in accomplishing this. From the great metropolitan supply furnishing water to Boston and 19 surrounding cities and towns down to the smallest supply, they are all practically at the present time safe, if we can judge from our typhoid death rate for the last few years as shown on the diagram; that is, the years since practically all our inhabitants have had access to good public supplies. The diagram shows that Massachusetts reached on the descending scale the satisfactory typhoid-fever death rate that I have quoted from Johnson and Sedgwick and Winslow twenty years ago, and since then the reduction has been so rapid that at the present time it is only one seventh as great as their ideal figures. It is of course open to question how much of the reduction from 20 to 2.6 is due to water and how much to other modern disease prevention measures.

In the state nearly 100 cities and towns have ground-water supplies, and the remainder use surface water. The ground waters are taken largely from driven wells 25 to 50 ft. deep, although many large curb wells are in use. These ground waters are, generally speaking, colorless, although there are a number of exceptions to this; they are usually soft, contain little organic matter, and many are equal to or better than the most famous or best exploited New England spring waters sold at high prices throughout the country. They are all generally low in bacteria, and many of them often sterile when examined. Such waters are, of course, absolutely safe without filtration or chlorine treatment, and their

introduction and use in so many cities and towns has undoubtedly had a great influence in lowering and eliminating typhoid in the state. They may perhaps be considered slowly filtered rain water. This water takes up in some instances slight amounts of organic matter when entering the soil, but this organic matter is eliminated or at least oxidized by the exceptionally slow natural filtration of the water on its way to the wells. As I have stated, a few need filtration to remove iron and manganese, but most of them are about as perfect and satisfactory in the line of water supply as the world contains.

Now, in regard to surface supplies the following can be said. Massachusetts is a thickly populated state, containing 3 851 000 people, or 419 per square mile, and our population is increasing rapidly. This population is largely concentrated, however, in the eastern or metropolitan section of the state and along certain river valleys where water power has been developed and railroad facilities are excellent. Large areas of the state contain no more inhabitants per square mile than one hundred years ago. These areas are frequently hilly and the rainfall high; their brooks, rivers, and lakes contain an abundant supply of good water. These waters before use are practically all purified by storage, and such slight pollution as may from time to time occur on their watersheds has so far been almost invariably sufficiently cared for by storage. They are low in bacteria when entering the supply systems, and the last water-borne typhoid epidemic in Massachusetts, due to a public water supply, occurred so long ago that I doubt a man present in this hall can state where and when it happened.

During the past few days I have had collected the typhoid-fever death rate of a large group of Massachusetts cities and towns using ground-water supplies and a group of cities and towns using surface water. The data gathered is not as complete as I could wish, owing to the limited time, but it covers a group of ground-water supplies supplying a population of nearly 400 000 people and of surface water supplies furnishing a group of a little less than 1 500 000 people. Included in the surface-water group is Boston and a number of towns and cities using the metropolitan water. These figures are for the ten years 1910 to 1919, inclusive, and are shown in the following table:

Typhoid-Fever Death Rate per 100 000.

Municipalities with	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Surface-water supplies...........	12.0	8.9	8.0	9.1	8.6	6.0	3.5	3.6	3.2	2.6
Ground-water supplies...........	12.9	6.6	8.1	4.5	8.1	8.9	6.7	2.8	2.4	3.0

Examination of the table makes clear that the two groups of municipalities have about an equal number of deaths yearly from typhoid fever per 100 000 people. There is no question that the ground-water supplies included in this table are absolutely safe, — bacterially they average better than the best filter effluents, — and it goes without saying that if

they are safe the towns receiving surface-water supplies and showing typhoid death rates as low, are receiving equally good and safe water. That is the story of Massachusetts to-day in regard to safety of water supplies without filtration and without chlorine treatment except in the few instances I have mentioned.

With figures such as these it is certainly going to be an uphill job for any one to persuade many municipalities in Massachusetts that their water supply needs filtration or other treatment for bacterial purification. It is probable that in most cities and towns expenditure of the public funds can for some time in the future be made in ways that will be of greater benefit to all concerned, yet as time goes on I have no doubt more filters will be built in Massachusetts not only as a still further barrier against disease and protection of health, but as a satisfactory method of improving water; that is, removing color, turbidity, tastes, odors, and other disagreeable qualities. Such accidents as that at Peabody, described by Mr. Weston in his paper, do occasionally occur even in Massachusetts, but such sources will eventually be abandoned or filtered. The newly organized state commission on "Water Supply Needs and Resources" has been appointed to study and report upon the future water supply of all the cities and towns in Massachusetts, and will undoubtedly among other things so increase the present metropolitan supply that towns now using water from not entirely satisfactory watersheds can enter this enlarged metropolitan system.

Discussion.

Col. George A. Johnson* (*by letter*). Mr. Clark, in his paper descriptive of what the Massachusetts State Board of Health has done to prevent water-borne disease, has given us for consideration the two horns upon which hang the hygienic question marks of municipal water supplies. He prefers innocence to repentance. Who does not?

The term "innocence" is capable of broad, but at the same time gravely circumscribed, interpretation. Paradoxical though this may sound, it nevertheless is strictly true. To be innocent is to be untainted, pure, blameless, innocuous, guileless, unstained. In another, but nevertheless precise, sense it is to be weak-minded.

Is it practical, is it possible, to maintain a surface water supply in a state of pristine innocence? There is no debate; it is not. All surface water supplies, including those of Massachusetts, are open to dangerous pollution at all times. Mr. Clark will not take the position that such Massachusetts supplies are "unstained," "blameless," and "entirely free from wrong." Many of them, perhaps all, are stained; many are not blameless, and none is perfectly spotless of potential sin.

Let us not be misled by the fallacious reasoning that through the admittedly efficacious work of the State Board of Health the surface water

* Consulting Engineer, New York.

supplies of Massachusetts stand alone as " innocent " waters, potentially infallible and impeccable. It must not be forgotten, as it so often is, that God has been good to the people of Massachusetts, and that by His grace, perhaps even more than to the efforts of the State Board of Health, the enviably good health record in Massachusetts respecting water-borne disease has been established.

Where there are growing communities there will be dangerous wastes produced by such growths. No man nor group of men can be depended upon to so care for those wastes that they will not in part, somewhere, some time, pass into the waterways which drain such populated areas. And always there is the potential danger that the water supplies derived from such watersheds will some time, somehow, become incidentally or accidentally polluted with disease germs. It is all very well to adopt a Yankee Doodle attitude in such matters, and to proclaim the excellencies of accomplishment without recourse to well-known and reputably established preventive methods of well-nigh infallible efficiency, but it is flying in the face of Providence to do so. Where other states are making use of every known means of protecting the health of their citizens Massachusetts, sufficient unto herself, continues to be willing to stand on the line of primary prevention, and to ignore such sure secondary and tertiary lines of defense as filtration and sterilization where such expedients are not positively demanded by the known gross pollution of the raw water supply. To be consistent with its policies of the past, which were right so far as they went in those unenlightened times, the authorities of this great Commonwealth are now willing to take a chance by failure to utilize every known means at their disposal positively and definitely to guard against the last fraction of potential danger to the public health which is afforded by every surface-water supply, no matter how carefully the catchment areas are patrolled, or how scientifically human wastes are diverted from the streams that drain them.

Innocence is indeed better than repentance; but it is equally true that, precisely speaking, there is no such thing as an innocent surface-water supply that may not at one time or another sow its wild oats of disease with disastrous results, unless every known precaution is taken to guard against such an accidental or incidental departure from the paths of water supply rectitude. One day the " innocent " water, protected from its cradle days by the solicitous hand of a jealous mother, may go wrong, and then —

" Amid the roses fierce Repentance rears her snaky crest."

In brief, the writer does not feel that Massachusetts is doing all that sound sanitary logic dictates. She has an enviable record respecting water-borne disease, brought about largely through the efforts of the State Board of Health in setting up lines of primary prevention, and also, as has already been pointed out, through the grace of the Almighty. Why

she does not avail herself of all the modern safeguards, in order to insure for all time a continuation of this good health record, is difficult of conjecture. However, being one himself, the writer may be permitted to remark that the New England Yankee is inclined to be "sot in his ways," undeniably stubborn and self-opinionated. These things may have a lot to do with the somewhat vainglorious attitude of Massachusetts to-day with respect to the protection of her public water supplies.

The above memorandum was mailed by the writer to Secretary Gifford the day before Mr. Clark's paper was read and, because of the writer's late decision not to attend the convention, necessarily was predicated upon the title of the paper as it appeared in the program, and gives a fairly precise knowledge of the viewpoints of certain of the Massachusetts authorities respecting water-supply matters.

Notwithstanding the fact that the writer's first comments seem quite pertinent to the contents as well as to the title of Mr. Clark's paper, he nevertheless feels that he owes Mr. Clark this explanation for assuming that the title of his paper was home-made and not ready-made, as it now proves to have been. Nevertheless, the writer continues diametrically at variance with the idea that such complete reliance should be placed in primary methods for the attempted control of water pollution, as is the custom in Massachusetts.

While, as a general proposition, the Massachusetts practice of forcing the abandonment of a water supply when it becomes contaminated is commendable so long as another purer supply can be developed to take its place, with economical factors always properly observed, valid excuse still is lacking for not in every practical way guarding against possible incidental or accidental contamination of every water supply derived from surface sources. Other states also force the abandonment of contaminated water supplies in favor of other purer supplies when financial considerations do not dictate the correction of such pollution as opposed to the more costly development of other sources of supply which in themselves may later become subject to contamination.

Mr. Clark states that the Merrimack River and its tributaries above Lawrence afford the only instance in Massachusetts where river waters into which municipal sewage is discharged are afterwards used for public supply. The writer hopes Mr. Clark will pardon him for expressing the opinion that this is merely a play upon words. The insidious entrance into a public water of the disease-germ laden wastes of one family, or even one individual, can create a powerful lot of disturbance in the interior mechanism of as many human beings as happen to drink that water, and that many public water supplies in Massachusetts are liable to such pollution Mr. Clark will not deny, the writer feels sure. All that is lacking, then, is for such contamination, even in small but highly dangerous amount, actually to occur, and the sophistry of not resorting to every available and

reliable means to prevent, so far as is humanly possible, even a single case of water-borne disease then becomes a stern actuality. The Peabody "accident" is a really minor, but nevertheless significant, case in point.

The fact remains, and is susceptible of no sound denial, that all surface waters, untreated before public consumption, are potentially dangerous. All the efforts and good intentions in the world cannot eliminate the possibility that some time a typhoid carrier, perhaps among the watershed patrol or a chance traveler over the watershed, or a leaky or overflowing cesspool or other point of deposition of the excrement of the inhabitants of an isolated farmhouse in which there is typhoid fever in incipient, active, or chronic form, will not contribute poison to a public water later used for human consumption, and cause typhoid fever in the consumer. Massachusetts, with all its State Board of Health efficiency and past good record, is no more immune from this grave possibility than are other states. It simply is a matter which is uncontrollable, except through the exercise of due diligence and uniformity of application in setting up such secondary and tertiary lines of defense as filtration and sterilization of all surface waters. Failure to recognize the soundness of this logic, which is founded on indisputable proof and past experience, may result in a repetition in Massachusetts of the typhoid history of Plymouth and New Haven, where the water supplies, taken from watersheds but sparsely populated, became suddenly and "accidentally" contaminated from one case of typhoid, and epidemics of proportions promptly followed.

The writer must be understood as in no wise attempting to belittle the truly remarkable health record of Massachusetts. It is a *fait accompli*, and susceptible of no criticism other than this: In public health matters one must not stand still, or, in other words, stand on a good record of the past. The potentialities of the present and the future must be jealously regarded lest the public health suffer, and the accomplishment of the past endure for naught and be speedily forgotten.

Where the public health is at stake, reasonable money expenditures are, or should be, no object, and the evidence is profoundly conclusive that any amount of money spent for pure water, if it prevents typhoid fever, is money well spent. The balance is always on the right side of the ledger. Parsimoniousness in such matters, or adherence to what the writer considers a "part-way" policy, such as that of Massachusetts, cannot be justified on any ground other than a mistaken idea of economy, or an ingrafted determination consistently to follow a custom conceived in the adolescent days of the art of water purification and general practices for the prevention of water-borne disease.

Mr. Clark. I think it was about one hundred years ago that Daniel Webster, in reply to an attack upon this state, said: "Massachusetts! There she stands," and I think if I point to this diagram, and the table, that is a sufficient reply to Mr. Johnson. (*Applause.*)

President Macksey. It is interesting for us to listen to men who

take entirely different points of view on a given subject, and the communication which you have just heard read is wonderful. It is written not only to instruct but to entertain, and it certainly has entertained. There is some truth in it, and there is no reason why we should not give it some consideration. It appears that the writer intended to place the Massachusetts Board of Health in the position of demanding protection of watersheds, and saying that that, in their opinion, was all that was necessary to do. That is not a fair statement. I do not think that the Massachusetts Board of Health has neglected to consider and to recommend the sterilization of waters where necessary, but in this part of the country the Yankee has obstinately stuck to the fact that water is a good beverage, and since the success — political success — of Mr. Bryan, Mr. Volstead, and other well-meaning but possibly mistaken gentlemen, the Yankee not only will have his beverage served to him, but he will, if possible, have it served as it was served to his progenitors. If we are to drink water we prefer it as God made it. We do not want it adulterated — well, we might make one exception,— a little Scotch — but if we can get pure water without sterilization, we prefer it. If we cannot, then we will sterilize.

We should neglect neither one argument nor the other. There is good sense in both. We all know many places where it is impossible to feel sure that we are protecting the watersheds, and therefore we can sterilize and be satisfied that the water is fit to drink. Filtration of the water supplies must become more general in this country. Our cities are reaching out for greater water supplies, they are encroaching one upon the other; and the consequence is that they are compelled to transport water over longer distances. That transportation is very expensive. The time will come when we shall probably decide that many of the lakes and ponds near our great cities can be filtered and served as potable waters at less expense than building aqueducts, pumping plants, etc., and transporting our water hundreds of miles.

Mr. Frank W. Green.* There is another member of the Association who has some different views from those expressed this morning. I wish to bring out a few points that may be of interest. In talking about filtration in Massachusetts it usually means sand filtration, and there has been no case where mechanical filtration has been given an opportunity to prove what it can do under conditions in Massachusetts, although it is felt by a great many of our prominent engineers that there are a number of towns in Massachusetts where there exists a very good opportunity to try out mechanical filtration.

In all cases it has been admitted several times during this convention that filtration is to be resorted to only in case of emergencies and where every other method fails. It has also been admitted that all your supplies have not been, from the moment they have left the clouds, pure and undefiled until reaching the consumer; that in some cases these waters may

* Superintendent Filtration, Montclair Water Company, Little Falls, N. J.

possibly and may probably become more or less polluted, and afterwards through storage have regained their fair name.

The quotation which is used as the title of this paper reminds me of another phrase which was used by a prominent attorney in New Jersey in a water case where the purity of the supply was demanded. The purity was not doubted, but it was said that the water had been one of these river supplies, and in summing up the attorney said, " It is purity and not pedigree which we guarantee." But the country as a whole undoubtedly looks to Massachusetts as being bitterly opposed to mechanical filtration or the use of chemicals in any shape or form unless absolutely necessary, and then possibly only temporarily. There are a great many engineers in this country, having the kindliest feelings towards Massachusetts, who regret that this is the attitude which men of Massachusetts take, as it was this state which did the first work along sanitation of public water supplies, and undoubtedly is still a leader in water-supply sanitation. The situation in Massachusetts is much better for impounding reservoirs, in used-up lands, untreated than it is in many other sections of the country, but the builders in these other sections expect those in charge of their supplies to get the same results by the same methods as Massachusetts; namely, not to use chemicals of any sort. In a number of cases, such as those larger cities of the Mississippi valley, this would be absolutely impossible. We see Chicago coming out as heading the low death-rate list from typhoid fever as given by the American Medical Association, with .5 per cent. deaths per one hundred thousand population in a city of several million inhabitants. In the case of the supply with which I am connected, we have been for a number of years in second place on this list. Sometimes one city and sometimes another has been first, but we have been second consistently. That is a river supply which is in a rather thickly populated section. There are about two hundred houses and bunkhouses eleven miles above the intake on this river. They are partially summer residences and partially used the entire year. That section of the river frequently has as many as five thousand people in bathing on the same day. Fishing and skating are indulged in. And notwithstanding those things, we have a number of times come in for the red ribbon. We have never won the blue as yet.

And I would like to emphasize again that Massachusetts cannot set herself apart from the rest of the country and consider that what she does is as much of interest to the rest of the country, because the leaders have not kept up with various improvements which have come since then; and there are a great many people who are fully conversant with the matter who feel that filtration has developed in spite of the Massachusetts State Board of Health, instead of because of it.

Mr. Henry A. Symonds.* What are the general details of your treatment?

* Consulting Engineer, Boston, Mass.

Mr. Green. The plan at Little Falls is a modern mechanical filtration plant designed by Mr. George W. Fuller in connection with the New York Continental Filtration Company, who constructed the plant. It was established in 1902. It supplies a population of between three and four hundred thousand people. That is the regular population. We also sell some water to Jersey City, running as high as fifteen or sixteen million gallons of water. After a time we put in a liquid chlorine apparatus, and still later began to manufacture our own chlorine and our own sulphate of alumina. We do not consider that chlorine is a perfect sterilizing agent, but we do consider that it is a sterilizing agent. I will say that when we find any better agent for sterilizing we will certainly try it out, at least, and if we find it satisfactory will change to ozone, or violet rays, or any other that happens to come along. The chlorine, of course, has the objection of taste and odor if used in excess, and it requires such a minute amount of chlorine that it is rather a delicate job to adjust it perfectly at all times. But that is being improved from time to time, and we always have the expedient of putting in another chemical to eliminate that effect, as is done in England, in case it really gets very bad.

Mr. M. N. Baker.* I think it might be interesting to find out the mistake of at least one community that is taking this water from Little Falls, and who have made almost violent attempts during the past year to get an independent supply. They are objecting very strenuously to taking water, even though it be purified to the highest state of the art, which is drawn from the same river shortly below the point where there is through the summer such an immense amount of bathing going on.

The whole subject of the paper and the discussion that has been submitted by Mr. Johnson opens up interesting possibilities that it is just as well on the whole not to go into at this time, further than to say that we must consider what the object of any city or any state board of health is in connection with the public water supplies. As regards satisfactory quality, we can rest assured that Massachusetts stands at the very topmost rank of any of the states in the country and in the world. There are, of course, arguments for putting in filtration plants, but each municipality in each state must be governed by its local conditions and by the results that have been secured. The Massachusetts State Board of Health and Massachusetts communities have been wide awake to the importance of pure and safe water, and they feel happy and contented in that fact, notwithstanding the extent to which some may feel regretful that chemical filtration has not yet been put into operation in the state. That, it seems to me, has a very great deal to do with some of the arguments that have been advanced by Mr. Johnson, and I feel perhaps that some of the arguments ought not to go into the record That is the opinion of many.

Mr. Clark. I do not really feel that Massachusetts quite deserves its reputation of being opposed to mechanical filters and the use of chemi-

* Associate Editor, *Engineering News-Record.*

cals as such. We all know — at least, I know — that some waters cannot be treated perfectly and efficiently by slow-sand filtration, and there are many states in the Union where mechanical filters have to be used. I have no doubt they are efficient. The State Board of Health in the old days had certain objections to such filters. The present department has, as chairman of its committee on water supply and sewerage, Prof. George C. Whipple. I do not think that Mr. Whipple has any prejudice against mechanical filtration, and believe he would consider the question of mechanical filtration in Massachusetts fairly, as we all would.

But our waters are of such character we feel that slow-sand filters can take care of them if any filtration is required. As far as liquid chlorine is concerned, we have no objection to its use, where necessary, as I stated in my paper. We have advised its use in three or four municipalities, — one of them in the past few weeks, — and the reason we do not have more chlorine plants is that we seldom need them and do not want them if we can get along without them. We seem to have gotten along pretty well, on the whole, without many filters or chlorine plants, as I think both the diagram and the table show.

REPORT OF COMMITTEE ON CHARGE FOR PRIVATE FIRE PROTECTION.

BY WILLIAM C. HAWLEY, CHAIRMAN.

[*Read September 8, 1920.*]

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — This committee has been in existence for four years. At the time of its appointment there was no method of fixing charges for private fire protection in general use. The rates charged ranged from nothing, in many cases, to "all that the traffic would bear" in others. There were no court or public-service commission decisions that were helpful, except that of the Maine Public Utilities Commission in the Portland case.

Most of the work of the committee has been done by correspondence. One meeting was held in Hartford, Conn., in 1917, and one in Albany, N. Y., last year. The war delayed the committee's work, but the members of the committee hoped that in the interim there would be some decision of court or commission which would help to crystallize opinion. However, there have been no such decisions; very few improvements have been made in rate schedules, so far as private fire-protection service is concerned, and we find ourselves, to-day, in practically the same position as that in which we were when appointed. We need not be discouraged at this, for it is less than twenty years that we have had any generally accepted method of segregating the costs of the various classes of service rendered by a water utility; and to-day, except in cases where rates have been established by the rate-making body, few water utilities, either public or private, have rate schedules based upon actual cost of service.

In view of the conditions of to-day, under which nearly every water department and water company finds itself obliged to seek additional revenue, your committee feels that it should present a final report, although we realize that it is only the expression of the opinions of the members of the committee, based upon a somewhat limited study of the problem, and does not have behind it the weight of legal decisions.

To your committee was referred the question of rates only, for private fire protection, and not conditions under which private fire-protection service should be supplied. This latter subject was covered exhaustively in the excellent report of the committee of the American Water Works Association, — Mr. Nicholas S. Hill, Jr., chairman, — which was presented to the Buffalo convention of that Association in 1919. These conditions, so far as they relate to rates for private fire protection, may be stated briefly as follows:

As a general rule, service connections for private fire protection should not be used for furnishing water for any other service. When other service is furnished through the connection for fire protection, a water meter, capable of registering flows with reasonable accuracy, at all rates from the largest to the smallest, should be installed on the connection.

Every service line for furnishing private fire protection should be equipped with a fire-service meter or other equally efficient means of detecting leakage or waste, and of indicating with reasonable accuracy any water taken from the fire lines.

The question of rates for private fire protection is one which has been before this Association for at least twenty years, and has caused some exceedingly vigorous and interesting discussions. Some have contended strongly that there should be no charge made for private fire protection. Others contended, with equal insistence, that water utilities should receive substantial remuneration for such service. Gradually we have come to realize that "there can be no such thing as 'free service.' Every service rendered without charge to the one who receives it is necessarily paid or compensated for by another, and consequently such service involves a question of discrimination."

A rate for service may be tested by a consideration of its cost to the utility and the value of the service to the consumer. Fortunately, neither of these is likely to limit the charges made for either public or private fire protection. Computations, to determine the investment necessary to render fire-protection service, invariably give it the benefit of any doubt; and in view of the very considerable saving in cost of insurance, to say nothing of the continuity of business and other benefits afforded by private fire protection, there can be no reasonable claim that private fire protection is not worth all that may be charged for it on the basis herein proposed.

The costs of service to a water utility are generally divided into three classes:

1. Capacity, or readiness to serve costs.
2. Output costs.
3. Consumers' costs.

So far as fire protection, either public or private, is concerned, output cost need not be considered. No charge is made for water used for fire protection. There is no satisfactory way of measuring water so used, and if there were, the amount would be too small to be considered. This is not saying, however, that water permitted to go to waste from private fire-protection lines, or taken from such lines for other purposes than fire protection, should not be paid for.

The capacity costs should first be determined, and those for public fire protection segregated. These costs should include such return upon capital as is proper, whether in the form of interest or dividends. The capacity costs, other than public fire protection, should then be pro-rated in proportion to the capacities of the service connections or the demands

of all of the consumers supplied by the water utility, and in this way a proper capacity charge ascertained for each size of service line. To this amount in each case should be added the proper consumers' cost, which should be sufficient to cover interest, depreciation charges, and taxes, if any, on the connection and meters, if same are furnished by the water utility, the cost of meter-reading, keeping the account, billing and collecting, repairs to service connections, meters, etc., and any inspection cost. The total for each size of service connection would give the proper service charge, and your committee believes that this service charge should be the same for any given size, whether the service connection be used for domestic, industrial, or private fire-protection service.

In view of the fact that rates based upon analysis of cost, such as has been indicated, will cover all of the costs to a water utility, your committee is of the opinion that the service charge should be the only charge for fire protection, — that is, that there should be no charge based upon the number of fire hydrants, hose connections, sprinkler heads, etc.

The committee realizes that very few water utilities have in use schedules of rates based upon costs of service as above indicated, and that in many cases considerations other than actual costs dictate what rates are charged for the various classes of service. In such cases no rule can be laid down, but since, as we have already pointed out, increasing costs of service are compelling many water utilities to seek additional revenue, we strongly urge that in all such cases costs of service be studied, and that in any new schedules rates shall be based upon cost.

Discussion.

Mr. H. A. Burnham.* The main report is a definite advance in so far as it seeks to establish a fair basis for charges with reference to cost of service and to exclude arbitrary charges, such as those based on number of hydrants or number of sprinkler heads.

I agree with the general treatment of the subject and with the main conclusion of the report, excepting for one point which might well be qualified, namely:

"Your committee believes that this service charge should be the same for any given size, whether the service connection be used for domestic, industrial or private fire-protection service."

The reason for this objection is that this expression places the charges for private fire service and for industrial service on the same basis, so implying they are in the same class, whereas the benefits resulting from the fire-service connections are much more far-reaching than the benefits from industrial connections which are entirely local.

Speaking from the standpoint of fire-protection engineering, as developed and practiced by the Factory Mutual Companies, the analysis of

* Inspector and Engineer, Associated Factory Fire Insurance Company.

the costs of the fire-protection service shows it to be desirable and fair that the effect of automatic-sprinkler service on the water system as a whole be recognized. There is now enough experience with sprinkler systems to show their effect as definitely beneficial to the community, and much of this experience has been accumulating in the large manufacturing plants here in New England.

Inasmuch as the automatic sprinkler as a fire-extinguishing instrument is recognized in many cities, to the extent that charges for these connections are waived, it is apparent that the service which the sprinkler renders puts its water connection in a special class. I believe the best interests of communities as a whole will be served by official recognition of this special class of service to the extent of specifically exempting the fire-service connections from this service charge.

Mr. Gorham Dana.* I should like to bring out one point which I did not hear mentioned in either report, and that is that the fire-service connection is an extension of the pipe hydrant connection, and I submit that any manufacturing plant has a right to public fire protection where the system is municipally owned. If they have a right to public fire protection, they certainly have a right to a private connection, which will put out a fire with less water, according to statistics. For this reason I believe the fire-service connection should be exempted from the charges.

Mr. James M. Diven.† Does the gentleman mean that the public should pay for this service, or should the water utility stand the exemption?

Mr. Dana. My idea would be that the user should not pay for the cost of installation that was in line with the public protection, or the use of water through private connections, for the reason that it uses less water in case of fire than the public hydrant, and he has a right to, and pays for them, in his taxes.

Mr. Diven. He pays for the public fire service, the same as any one else; and if he requires a special fire service, it is a special privilege which he should pay for.

Mr. George S. Davison.‡ I agree with Mr. Diven; where there is a private fire protection it should be paid for by the firm or individual. You cannot expect a community to pay for a watchman to look after a man's or firm's property. They have the benefit of the general police force for their public protection, but if they want a special watchman to look after their interests, or special fire protection, they should pay for the service.

I think the trouble is in confusing the meaning between the public and private protection. I believe that the time is coming when the underwriters will oppose all large connections from 4 in. up, because there is a constant menace and danger where large connections are established,

* Manager Underwriters' Bureau of New England.

† Superintendent Water Works, Troy, N. Y.

‡ President Gulf Refining Company, Pittsburg, Pa.

due to the breaking off of the risers, leading to the upper floors, when the fire gets beyond the control of the automatic sprinklers, — and that has occurred in a number of cases, placing the general fire protection at a great disadvantage. I have in mind one case where a 6-in. line supplied a number of automatic sprinklers, which failed to put out the fire, while the walls fell out and broke off the 6-in. connection, and it was impossible to maintain fire pressure. If at that time a fire had broken out in the high hazard district it would have led to a serious conflagration, because the water works simply could not maintain fire pressure when the 6-in. stream was discharging in the basement. You may ask, "Why not shut it off in the basement?" The brick walls fell outwardly and covered the valve with red-hot brick, so it took quite a while to get at it.

Mr. Dana. The only point which I should like to make is, that you will use less water with private protection.

Mr. Davison. To emphasize what the last speaker has said, let me state that I had occasion to examine into the question of what amount of water is necessary to put out fires in a city of several hundred thousand inhabitants. I went to the fire department and got a complete record of every minute that every fire engine was out of the firehouse, whether it left the house to answer a false alarm or not, calculated the capacity of the pumping engine, and what water had been used for fire purposes during the year. In this city, at this particular time, the use of water was very high. It ran to about two hundred gallons per day per inhabitant. The result of my calculations was that the amount of water that could have been used by the fire department, or was used, was a pint a day per inhabitant.

Mr. Hugh McLean. I think this is a very appropriate time to discuss this matter, and it is applicable to Holyoke, as we all have similar problems that confront us. It does not seem to me that any corporation, such as we have in Holyoke or elsewhere, would complain about being charged an equitable and just service rate for fire protection, such as your report recommends. In these days of the high cost of all things, I think we ought to consider the service rendered and apply an equitable and just tax for service and fire protection. To raise the rates is the last thing to be done. We cannot raise the rates here in Holyoke by simply a vote of the water commissioners. We must first have the consent of the board of aldermen upon petition, and that petition must be reviewed by a judge of the Superior Court before we can raise our rates. So you see the public is amply protected by the statute. Very likely the judge of the Superior Court would ask us questions regarding this particular case of fire service, and I think it would be well if we were able to show just the conditions and why we are justly entitled to charge for service rendered for fire protection. We have been furnishing service for nothing for a long time.

Mr. Percy R. Saunders.* While I think a charge should be made

* Superintendent Water Works, Concord, N. H.

for fire service, here is a fact that you cannot get around, viz., that we are established, and have got a lot of men in the town who own their homes. You have to figure that the water works, if the city owns it, is established for the purpose of rendering the greatest benefit to the greatest number of people. If a factory burns down, the employees are thrown out of employment, the chances are that they may not be able to get employment in the same town, and may have to go away.

Mr. Frank D. Davis.* It seems to me there ought to be a little difference made in the amount of service. If I understand the report, there should be a service charge. If you have a 6-in. pipe, it makes no difference what is to be used off that service.

In our case, I will give you two instances: One, a small factory for which the underwriters required a 6-in. connection. Another factory, which has something like three or four thousand hands, has the same specification. That does not seem to be a fair proposition. It seems to me that in this ruling — the service charge is all right — there should be a flat service charge in proportion to its use. We have a big concern that has over a hundred hydrants, and they have an 8-in. connection. It would seem better to make a difference between them and to graduate them in some way. We have two similar cases in which one employs four hundred and another about three hundred. In one case they have six hydrants and about three thousand sprinkler heads.

Mr. W. C. Hawley.† One or two matters have been brought up which I think it might be well to touch upon. The gentleman who last spoke seems to have stated instances where the lines were not proportional to the demand. If the service charge is properly made, we are going to be relieved of some demands for excessively large services.

Regarding this question of benefit that you are speaking about: If this fellow has put in a lot of fire-insurance protection it may be true that the community is indirectly benefited in that way, and that the owner of the factory is entitled to some consideration, but, if so, it should be by the community and not by the water utility.

Then, the argument is made that because we have a sprinkler system less water is used in putting out a fire. On the whole, it is probably true, and probably in ninety-nine cases out of a hundred much less water is used; but I want to tell you a little experience we had, a few years ago. A large factory with sprinkler system, hose connections, and all of the up-to-date connections, was supposed to be absolutely fireproof. They had some very cold weather and could not keep up steam enough to keep the building warm, and some of the hose lines and sprinkler lines froze, so that it was necessary to make repairs. One Saturday afternoon when the factory was closed, with very few men there, some fellow who was too lazy to shut off the proper connection, shut the main valve just inside the

* Superintendent of Water Company, Ansonia, Conn.

† Chief Engineer and General Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa.

yard. Fire broke out. There was no water, and the whole factory was burned. Between the time that the fire broke out and the time I got there, they had got the valve open and water was going through the detector meter, but meanwhile they brought eleven fire streams from the fire hydrants outside. As the building burned, we could see from the outside, here and there, water running in all directions, where the sprinkler pipes and hose pipes had broken. Afterwards the insurance engineers made an investigation to see how much water was going into that factory line. They found that some thirty-three hundred gallons per minute were going to waste, and the eleven fire streams brought in from outside were doing the work. If we had not been so fortunate, a few months previous, as to make pipe extensions which enabled us to take care of this enormous demand, there would have been head-lines in the papers next morning that the water supply had failed entirely. You may say that this is an exceptional case, but it serves to show the demands which private fire protection systems can make and that it is something we have got to consider.

The service charge that is proposed is not a serious thing. It is not a fraction of what the owner would save eventually in his fire protection. If it were putting a big load on him, it might be different.

RESOLUTION.

SEPTEMBER 10, 1920.

It is the desire of the New England Water Works Association and Water Works Manufacturers' Association to tender sincere thanks and appreciation to the Mayor and Aldermen, the Chamber of Commerce, the Rotary Club, and all the good citizens of Holyoke, who have coöperated in so hospitable a manner in welcoming and entertaining this convention.

Particular mention should be made of the works of the Local Committee of Arrangements, under the energetic and able direction of Mr. Thomas J. Carmody, who has labored night and day to insure a good time for everybody.

Special thanks are also due to our good friend, Patrick Gear, who has been on the job every minute in order that when it came time for the convention to end, the impression should be left in every one's mind that Holyoke is in truth a "friendly city."

H. V. MACKSEY,
President N. E. W. W. Asso.
EDGAR J. BUTTENHEIM,
Chairman Entertainment Committee,
Water Works Manufacturers' Association.

REPORT OF COMMITTEE TO CONSIDER ADVOCATING THE USE OF A BOND INSTEAD OF A CERTIFIED CHECK TO ACCOMPANY PROPOSALS.

[*Read September 10, 1920.*]

In municipal, state, and United States government work, there are two methods in common use of binding the bidders to their proposals and making it necessary that a bidder shall either sign the contract, if it is awarded to him, or forfeit a sum which is considered in some measure at least to reimburse the owner for the trouble and expense to which he is put in case the contract is not signed by the party to whom it is awarded, and the difference between the proposal made by the bidder to whom the contract was first awarded and such other proposal as may be accepted.

One method is to require that the proposal be accompanied by a certified check for a definite amount. These checks are returned to the unsuccessful bidders, after it is evident that their proposals will not be accepted, and to the successful bidder at the time the contract is signed, at which time a bond is given for the faithful fulfillment of the contract.

The other method is to require that the proposal be accompanied by a bond issued by a responsible bonding company, guaranteeing that, if a proposal is accepted, the bidder will sign the contract within a specified time; or, in case the bidder shall not enter into the contract and give a bond for the faithful fulfillment of the contract, the bonding company guarantees to make good the difference between the offer of the bidder and that bid which may be accepted.

Some of the objections to the use of certified checks are as follows:

It necessitates the tying up, or putting out of circulation, for the period during which a decision is being reached regarding the award of the contract, the money of all the bidders, which sometimes is for a considerable sum for a considerable time. Checks are sometimes lost or misplaced, thus causing trouble and annoyance to the bidder. If a check is lost, the bidder is obliged to bond himself to the bank to get a reissue of the check.

Checks require care for their safekeeping, which is not desired by many owners.

Your committee has not heard and does not know of any objections to the use of a bond instead of a check.

The Association probably cannot pass any resolutions which would bind a member to one method or another in conducting his business, but the committee is of the opinion that it would be well for the Association to pass a resolution recommending the use of a bond instead of a certified

check with proposals, and recommends the adoption of the following resolution:

RESOLVED, that the New England Water Works Association recommends that when bidders are required to accompany their proposal with some guarantee of good faith, a guarantee bond be required, rather than a certified check.

Attached is a copy of one form of a bond, with names omitted.

CHARLES T. MAIN.
H. K. BARROWS.

[COPY.]

GUARANTEE ON THIS PROPOSAL.

TO THE COMMISSIONER OF ....
CITY OF ....

The undersigned..................INDEMNITY COMPANY, a corporation duly organized under the laws of the state of.................., and having a usual place of business in.................., hereby guarantees that in case the attached proposal of the..................for furnishing.. ....in accordance with the accompanying schedule, be accepted, the bidder will, within ten days after the receipt of notice of such acceptance, execute the required contract for the same and give bond, with good and sufficient surety; and in case the said bidder shall fail to enter into such contract and furnish said bond, as aforesaid, we guarantee to make good the difference between the offer of the said bidder and that which may be accepted.

WITNESS OUR HANDS AND SEALS this..................day of................ 19 .

INDEMNITY COMPANY.

By..
Attorney-in-fact.

ATTEST: ....
Attorney-in-fact.

DISCUSSION.

MR. REEVES J. NEWSOM.* I think the only difficulty is that the city ordinances have to be consulted in adopting such a plan. It is not a matter of choice. In a great many cases there are city ordinances which require certified checks. It may be that we will meet with some difficulty in getting those changed, even though this is adopted.

MR. W. C. HAWLEY.† It would seem to me that the certified check becomes the property of the city, and that check can at once be deposited or cashed. Personally I would rather have a check than a bond. I may be wrong in the premises, so far as the legal side of the question is concerned. But in a private company you have the benefit of choosing your patrons; and if a man submits a bid, whose reputation is not such that we can deal

* Commissioner of Water Supply, Lynn, Mass.
† Chief Engineer, Pennsylvania Water Company.

with him, we can reject the bid and pay no attention. So that, as a rule, our company does not bother with a certified check or bond.

Mr. Charles W. Sherman.* Our office had occasion, a short time ago, to examine a contract for a piece of public work to be performed for the city of Dayton, Ohio. The portions relating to certified check or bond were, of course, drawn in the usual form, followed by the city, and with which we had nothing to do. But, as a matter of interest, it may be worth while to note that they provided three options, any of which the bidder could comply with. The first was the usual certified check; the second, the bidder's bond; and the third was a deposit of Liberty bonds to the par value of the certified check required.

Mr. Wm. A. Mackenzie.† I have a case in mind which occurred two or three weeks ago, where in awarding contract for sewers the low bidder happened to be an undesirable contractor who failed on a large job in town. If we had asked for a bond, it is very probable that the surety or bonding company would not have cared to furnish one, and in that case it would have served to eliminate this party from consideration.

President Macksey. In regard to the matter of the accompanying of check or bond we have two different cases to consider, viz., where the bid is called for by a municipality, or some division of the government, or where by the representative of a private company.

When a private company hires a man and gives him authority to ask for bids and arrange for contracts, it assumes that it has engaged a man who is intelligent and who is honest, and therefore the responsibility is placed upon him, and it is left with him until his employers feel sure that they have made a mistake, either in regard to his ability or his integrity. If they find that they have made a mistake, they don't call a meeting of the board of directors or the stockholders and proceed to fence him around with all kinds of restraining rules and regulations. They send him to the paymaster and he is relieved from further duty.

In municipal employment, that is not the common custom. The people elect certain men, and those men appoint certain officers. And then, for fear that the officers appointed might be either kleptomaniacs or lunatics, they are fenced around with rules and regulations to protect all parties except the officers who are responsible for the work.

If one is employed by a private corporation and has an important job to do, he looks over the list of known men who are competent to do it and on whom he may rely, and does not forget that there may be a new man who has had proper experience and on whom he might take a chance, and such men are invited to bid upon the work.

It seems to me that no one should invite a man to bid upon work unless he thinks that that man is competent to perform it, and also competent to estimate what it will cost. Therefore no surety is needed that

* Of Metcalf & Eddy, Boston, Mass.

† Superintendent Water Works and City Engineer, Wallingford, Conn.

a man will sign his contract, because if a man has made a serious error in his estimate, such that he could only perform the work at a loss, it is the duty of that officer knowing the facts to reject the bid; one can never get a good job from a man who is losing money on it. I don't care who the man is; his money is at stake, he naturally attempts to save it every way that he can. No matter how rigidly one enforces regulations by inspection, he cannot get a good job done unless he is willing to pay for it; and if he takes advantage of a mistake by a contractor the latter will take advantage of carelessness or lack of thorough inspection.

If one advertises a public letting, every Tom, Dick, and Harry may bid, and he may get bids from undesirable parties.

Under such conditions I feel that the officer who awards a contract is justified in throwing out any bids if he can see a just reason therefor, such as the unreliability of a bidder personally or financially. In other words, if he has not the knowledge, or plant, or capital to do the work, or if he is not a man of a fair, square, and agreeable nature, one that he can get along with. If one is allowed to select bidders, to invite bids instead of advertising publicly, I see no need of check or bond with a bid, for if you allow a man to bid who is willing to crawfish, the sooner you are rid of him the better. One can then check this party off his visiting list, one that he does not care to see again. If one is bound either by statute, ordinance, or regulation from higher authorities to require some kind of a bond with the bid, I believe that the certified check is the safest and best. As far as putting money out of circulation is concerned, it does not put money out of circulation. If the bank certifies a check for a thousand dollars, it does not put a thousand dollars out of circulation. Outside of a loss of the interest upon that money for a very short time, the man who asks for the check loses nothing. Whereas, if he goes to a bonding company he does lose, because he not only loses interest — but also their overhead charges and profit. There is this to be said about taking a bond instead of a check: One cannot always get the authorities of a city or town to insist upon a surety company bond. A bond given by local citizens who are known to be financially responsible is as good. If you are sure that that is the kind of a bond that you get, and you are sure that the man's property will not be disposed of before the bond comes due, all is well. I think that the system of a surety bond is much better than to accept bonds from persons who make no profit from them, and who merely give bonds as a matter of friendship. It is not always pleasant for the official who has to accept such a bond to investigate whether the aforesaid citizen really has the property named or only an equity in it, or whether the title is in his own or his wife's name. If we are to have a bond I believe in a surety bond. If a bond forwarded with the bid is to be forfeited, the difference between the price which it bonded and that of the contractor to whom the job is awarded should be charged against the bond. If a bidder should find that he has made a serious mistake in his bid, and that he must decline to con-

tract,— and he certainly has that right if the only penalty is the loss of his bond,—he should not be placed in a position where the contract may be given to the highest bidder and he must pay the difference in cost. The officials should not be placed in a position where they are bound to award to the next lower bidder or have a fight on their hands.

In my opinion, of the two, the certified check system is the best, and the loss due to holding checks can easily be avoided by prompt action upon the part of the officials who made the award. I believe that if there is delay of any great length in awarding the contract every bidder should be allowed to withdraw his bid, if he sees fit, because it has never been fair, and to-day it is manifestly unfair to hold the bidder if he cannot do the work promptly, as the conditions under which he contracts for machinery, labor, etc., may change greatly to his disadvantage. I am not in favor of the Association endorsing the recommendations of the committee.

REPORT OF COMMITTEE ON STANDARD SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS, NEW ENGLAND WATER WORKS ASSOCIATION.

MR. FRANK A. MC INNES, CHAIRMAN.

So long a time has elapsed since this committee was appointed, and so much work has been done without results, that the following review of our past endeavors to revise existing specifications and a brief statement of our future intentions is submitted.

In 1911 a Committee on Revised Specifications was appointed by the American Water Works Association, and in the following year the New England Water Works Association took similar action. Much work was done by your committee during the next three years — both independently and in coöperation with the committee of the American Association — the development of one standard specification acceptable to both associations being early recognized as the *sine qua non* in the problem of revision. Accordingly, in January, 1916, a joint committee consisting of three members from each of the two committees was appointed, and a tentative draft of revised specifications, prepared by this joint committee, was sent to the manufacturers of cast-iron pipe on May, 1916, " for their discussion and criticism." The outstanding feature of this tentative draft was the adoption of a uniform outside diameter, within practicable limits; in this the committee believed it was expressing the consensus of opinion of the members of the two associations. Other proposed revisions were the adoption of a permissible range of total carbon, combined carbon, silicon, manganese, and sulphur, and a required relation between flexure and breaking load of test bars.

In December, 1916, the joint committee met a representative gathering of manufacturers in New York City. It was at once evident that the producers were decidedly opposed to the uniform outside diameter on the grounds of increased cost and difficulty in manufacture. After prolonged discussion, in which the non-producing members sought to obtain from the manufacturers definite statements as to the practicable limits of a uniform outside diameter in different sizes of pipe and as to the extra cost involved, it was unanimously voted that the manufacturers should further consider the tentative specifications and report " the result of their deliberation, with such modifications, paragraph by paragraph, as may seem to them desirable, together with their reasons therefor." It was the understanding of those present that any reasons against a uniform outside diameter would include detailed statements of the practicable limits of building up the material on core bars and of the extra cost involved. With this information

as to the exact cost of a uniform outside diameter in hand, the committee believed the membership of the associations would be in a position to better judge whether the change justified the expense.

Instead of making such a report to the committee on the date named (March 15, 1917), the manufacturers, on May 31, 1917, wrote an unfortunate letter, briefly stating that in their opinion the American Association Specifications had proved fairly satisfactory, as evidenced by their almost universal adoption, and that no revision was necessary. This letter raised the direct question as to the demand for a revised specification, and the next step of your committee was to submit the issue to the membership of the Association and thus obtain a mandate as to its further action, particularly in reference to the uniform outside diameter. Accordingly, at the annual meeting in January, 1918, it was recommended by your committee and adopted by vote of the Association that the report of the American Committee — made to that association at the Richmond Convention in May, 1917, which report was the work of the joint committee of the two associations — be printed and distributed to the membership of this Association; that at the next monthly meeting after such distribution the subject be thrown open for discussion, and that during the month following this discussion a questionnaire be sent out. This program was followed, the following being a copy of the Questionnaire, with a statement of the replies received:

QUESTIONNAIRE.

With the understanding that no change would be made in the Standard Specifications for Cast-Iron Pipe and Special Castings until after the present World War has ended, and not then until after a reasonable period has elapsed for the manufacturers to revise their equipment, —

1. Do you think a revision of the existing specifications desirable? [Yes, 84; no, 10.]
2. Are you in favor of the adoption of a uniform outside diameter? [Yes, 81; no, 16.]
3. Are you in favor of specifying chemical requirements of the metal? [Yes, 74; no, 13.]
4. Are you in favor of a relation between flexure and breaking load? [Yes, 65; no, 11.]

Eighty-five per cent. of the replies received were in favor of all the principal changes proposed in the tentative specifications, but less than 15 per cent. of the membership of the Association replied to the Questionnaire. Should this result be interpreted as a general lack of interest in the revision of existing specifications, or that the responsive 15 per cent. fairly represented the feeling of the silent 85 per cent., and that therefore the Association is in favor of a uniform outside diameter, and that contrary to the opinion of the manufacturers there is a demand for revised specifications?

The committee was, and still is, in doubt; certainly the response to the Questionnaire is open to more than one interpretation. At all

events, the World War and following conditions made the work of revising specifications one of the "unnecessary industries," and no further definite progress has been made since 1918. Contact with the manufacturers has, however, been continuously maintained by interview and correspondence, with the result that a better spirit of coöperation has developed, although the contention of the majority of producers that a uniform outside diameter is neither practicable or demanded remains unchanged; in this they are "from Missouri," and "must be shown," and to this end the joint committee proposes by further correspondence with those members of the two associations who are best able to assist in formulating a sound judgment as to whether there is a demand or not for a uniform outside diameter. In no other way can this question be settled. A uniform outside diameter within certain limits can be made at a cost and will be furnished by the manufacturers if called for by a demand which represents the bulk of the consumption. From the users' standpoint there are arguments both for and against this change in the specifications. For new work and looking toward the future, a uniform outside diameter is desirable; for repairs and connections to old work there is some question. No matter how valuable in future enlargement of the water systems of this country, its present incorporation in specifications can only be made effective by an immediate demand which the manufacturers must recognize. To satisfactorily determine whether such demand exists is yet to be done by your committee.

While it is true that the adoption of a uniform outside diameter will only result from an insistent demand of consumers, there are certain recent developments in the manufacture of pipe which have a bearing on this phase of the revision problem. One of these developments, the use of new methods of core making, where the thickness of material upon the core bar is reduced to a minimum, makes a uniform outside diameter less feasible than with the older methods. On the other hand, one company is producing a high tensile iron developed by high temperature in electric furnace, and with this iron the range in thickness for different classes of pipe is so much reduced that the difficulty of obtaining a uniform outside diameter without too great multiplication of core bars, is, in great part, removed. Believing that these developments justified personal investigation, two members of your committee — its chairman and Mr. W. R. Conard — visited the southern foundries in April of this year. Four days were spent in the plants of the U. S. Cast-Iron Pipe and Foundry Company at Birmingham, Bessemer, Anniston, and Chattanooga, and one in the plants of the American Cast-Iron Pipe Company and the National Pipe Company at Bessemer. Three evenings in Bessemer were employed in conference with the local managers of the four pipe foundries in that neighborhood. Ample opportunity was afforded for observation of the work of pipe making in all its phases. The manufacturers evidenced a desire to assist your representatives in every possible way, and much information was obtained which will be of use to the committee.

In one foundry of the United States Cast-Iron Pipe and Foundry Company the use of core bars, already referred to, with a minimum thickness of material was observed. The method is claimed to produce uniformly smooth inside walls and has been adopted for this reason. It is in line with the manufacturers' contention that with the greater thickness of material on the core bar, necessarily incidental to a uniform outside diameter, it will be difficult to make pipe with smooth interior surfaces. The product as observed was noticeably clean and smooth.

In the foundry of the American Cast-Iron Pipe Company, iron with a tensile strength of 30 000 to 40 000 lb. per sq. in. was being used — made possible by high temperature treatment in an electric furnace of a metal partly taken direct from a blast furnace and partly from the foundry cupola. In the same plant, pipes 4 in. to 12 in. diameter were being cast in 16-ft. lengths, and were shipped with a prepared joint in bell ready for driving. In this plant also, where casting "bell up" was the practice, the record of a series of tests of pipes thus made purported to show that in pipes 4 in. to 12 in. diameter the tensile strength of the metal was materially greater at the top than at the bottom of the pipe mold.

The feasibility of using iron of greater tensile strength than in the past is a matter of general interest in the problem of revising specifications. The old line manufacturers say they have been all through this question and are convinced that high tensile iron and the resulting thinner pipe cannot be made a success. Such pipe are however being sold, and, in this age of advancing freight rates, the possibility of reducing weight is becoming an important consideration.

In reference to the question of "bell up or down," tests have been undertaken for your committee by two manufacturers to determine the relative strength of metal at different points in the length of a pipe cast vertically. Also growing out of the southern trip arrangements have been made whereby a number of producers in different parts of the country will make tests showing deflection of a standard 2 in. by 1 in. bar, 24 in. wide, between supports — at 1 800 lb. and at increments of 200 lb. up to the breaking point, and also to determine chemical characteristics of each bar broken. In this way it is hoped to establish a relation between the physical and chemical qualities of the metal, and possibly to show that with a specified increase in flexure for each increment in breaking load a specification of the chemical quality of the metal may not be necessary.

Another interesting development in the making of pipe is the DeLavaud centrifugal process, in use at the plant of the National Iron Corporation, Toronto. By this method the iron is poured into a horizontal mold revolving at high speed, which centrifuges the metal against the mold to the desired thickness. The pipe so made is said to have a tensile strength of 35 000 to 39 000 lb. per sq. in., as compared with pipe cast from the same heat of metal in the ordinary sand mold. Obviously this method particularly lends itself to a uniform outside diameter.

Only time can disclose what bearing any of these new developments will have in the future on the art of making pipe, but obviously they may have a bearing on the revision of existing specifications. Under present conditions it is believed that the wise course for your committee to pursue is to maintain a close contact with manufacturing progress, to proceed with the tests above mentioned, and to take all possible steps to secure the fullest information regarding the questions at issue, particularly that of the demand for uniform outside diameter.

DANIEL B. McCARTHY.

Daniel B. McCarthy — born in Weavertown, N. Y., January 1, 1871 — was the son of Patrick and Mary McCarthy. Mr. McCarthy died at his residence, 35 Fort Washington Avenue, New York City, March 6, 1920, after a brief illness of less than a week, of bronchial pneumonia.

Mr. McCarthy in his earlier years attended the local schools, completing his education at the Troy Business College.

He was first employed by the well-known firm of water-works builders, Moffit, Hodgkins & Clark, of Watertown, N. Y., at their plant in Watervliet, N. Y., where he remained for about a year. From there he went to their Waterford, N. Y., plant, at which place he was superintendent for nearly twenty-one years, until the village of Waterford purchased the water works. During his management at Waterford, he associated himself with the Neptune Meter Company and represented that concern for nearly seventeen years, traveling in the eastern states and Canada. In May, 1914, he was made the eastern sales manager of the company, and was in direct charge of the sales for a large portion of the country.

Mr. McCarthy was married in Waterford, N. Y., in 1896, to Miss Catherine Esmond, who with one son, George H. McCarthy, a graduate of Cornell University, survives him.

Mr. McCarthy was a member of the Roman Catholic Church, the Corrigan Council of the Knights of Columbus, the Troy, N. Y., Lodge No. 141 of Elks, the American and New England Water Works Associations, and the Machinery Club of New York City. He was a man who had a large acquaintance and many friends. It was a pleasure for him to help those he knew.

The interment was in Waterford, N. Y., March 9, 1920.

John Knickerbacker.
John M. Diven.
James M. Caird.

ROBERT WINTHROP PRATT.

Robert Winthrop Pratt, consulting, civil, and sanitary engineer of Cleveland, Ohio, was born at Brookline, Mass., on December 21, 1876, and died February 2, 1920. He was the son of Grace Otis (Kellogg) and Robert Winthrop Pratt, and traced his ancestry to John Alden.

He was graduated from the Boston Latin School in 1894, with high rank, and entered the Massachusetts Institute of Technology the same year; where he completed a civil engineering course in 1898, receiving the degree of bachelor of science.

Mr. Pratt then served as engineering assistant to the Massachusetts State Board of Health, where he had previously been employed during school vacations. Later, he was employed as instrumentman on grade-crossing work, in the Engineering Department of the Boston and Albany Railroad. In June, 1899, he returned to the Massachusetts State Board of Health, as assistant engineer, and was engaged in making investigations and preparing reports on existing water supply and sewage works in the state, and also preparing reports on plans for proposed work.

In June, 1903, Mr. Pratt became chief engineer of the Ohio State Board of Health, in which position he was required to investigate and pass upon several hundred plans for proposed water supply and water purification, sewerage, sewage treatment, refuse and garbage works. His recommendations were used as a basis of action by the Board of Health in acting upon plans. He was also placed in charge of a special investigation, by authority of the legislature, of all existing water purification and sewage treatment plants in the state. During this time he served a number of cities in Pennsylvania and also the city of Wyandotte, Mich., on problems connected with water supply and sewerage. He also acted as special hydrographer of the United States Geological Survey, and was in charge of the gaging work then being conducted by that department in Ohio.

From July, 1910, to July, 1911, when on leave of absence from the Ohio State Board of Health, he held the position of director of sanitary engineering for the republic of Cuba. He was engaged in making investigations and recommendations for the improvement of sanitary conditions, as well as for plans of water supply and water purification for a number of Cuban cities.

Mr. Pratt was joint author with Prof. L. P. Kinnicutt, of Worcester Polytechnic Institute, and Prof. Charles E. A. Winslow, then of the Massachusetts Institute of Technology, in the comprehensive and favorably received text and reference book, entitled "Sewage Disposal."

From 1911 to the time of his death he maintained an office in Cleveland, in the practice of civil engineering, largely upon municipal work. A large portion of the time was spent on work for the city of Cleveland, in the design of the filtration works, and in making investigations for the treatment of the city sewage. During the last ten years he was retained by many city, county, or state governments in consulting, designing, and supervising work. His work covered principally Ohio, Pennsylvania, Michigan, and Ontario.

During the World War he was employed by the United States War Department as supervising engineer on the construction of Camp Sherman, Chillicothe, Ohio (capacity 40 000 men), one of the original sixteen cantonments; planning and directing the construction of water supply, drainage, sewerage, sewage treatment and roads. He was also engaged by the United States Shipping Board to supervise utilities necessary for industrial housing developments in Wyandotte, Mich., and Lorain, Ohio,

and similarly served the United States Department of Labor on its housing project at Alliance, Ohio.

The most important work in Michigan was an investigation of the Detroit water supply, with reference to filtration and other improvements, including the supervision of the operation of a demonstration filtration plant. At the time of his death he was connected with several projects of various kinds.

Mr. Pratt was a member of a number of professional societies, as follows: American Society of Civil Engineers; New England Water Works Association; Boston Society of Civil Engineers; Engineers Society of Pennsylvania; Cleveland Engineering Society.

Probably no better tribute can be written than that prepared by his classmate and lifelong friend and associate, Prof. C.-E. A. Winslow, of Yale University, who in writing for the *Technology Review* says in part:

> "To those who knew the man and knew his work, these summary statements of positions filled and work accomplished are significant of a unique and fruitful public service. The science of municipal engineering at many points bears the impress of Winthrop Pratt's constructive vision, for he never feared to do the new things which his clear and alert mind felt to be sound and practical. The immediate and tangible results of his labors are seen in hundreds of municipalities in this country and in Cuba, and thousands of men and women have been safeguarded from water-borne diseases by the sanitary works which he made possible.
>
> ". . . Behind the work and in the work is the man; and it is of the man, Winthrop Pratt, that his classmates are thinking with a sense of keen and vital loss. His big frame and his slow, kindly smile were the outer signs of a nature that was at once strong and gentle. He was a tireless and enthusiastic worker, a clear and sound thinker, a born business man with a Yankee love of bargaining. Yet he was always patient and fair-minded and considerate of others. His contracts were secured because his integrity inspired confidence. His subordinates were devoted because his character won their complete loyalty. Winthrop Pratt's life was a successful life. His friends, while they mourn a deep and personal loss, can feel proud of a career which even though cut short in its prime is builded imperishably into the progress of engineering and the development of our country, and of a life which leaves behind it the memory of a strong and upright and lovable man."

Mr. Pratt had a pleasing personality which gained friends for him wherever he went. He had a broad outlook, and radiated confidence and good-will. On June 1, 1903, he was married to Elizabeth Southwick, of New York City, who survives him, with two sons and two daughters. After a short illness of pneumonia, he passed away at his home in Cleveland, on the morning of February 2, 1920. The engineering profession loses an earnest student and his associates a cordial and sincere friend.

This memoir was prepared by George W. Fuller, E. G. Bradbury, and Morris Knowles, members of the New England Water Works Association.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

LEAD POISONING BY WATER, AND ITS PREVENTION.

BY ROBERT SPURR WESTON.*

[*August 20, 1920.*]

While much has been written under the same title as this paper, experiences in practice, during the last few years, have brought forth facts which have not been published in water-works journals, and which throw new light on the whole problem.

Historical.

It is no new statement, that certain waters take up enough lead from service pipes to cause lead poisoning (plumbism) when drunk by certain susceptible persons. Lead poisoning was first noticed by the ancients. Hippocrates was well acquainted with it. Galen,† the Roman physician, wrote an account of the disease and described the harmful action of water on the large, lead service pipes which were then used in Latin cities. Vitruvius,‡ an architect who was a contemporary of Augustus Cæsar, forbade, as did others, the use of lead pipe for conveying water.

In the middle ages lead poisoning was quite common, owing to the ancient custom of conveying waters to public fountains through leaden pipes. The only reason why it was not more prevalent was because most of the then civilized world used comparatively hard waters, which had only a slight action upon lead.

In Great Britain, in the early part of the nineteenth century, a number of cases were noted, particularly at Tunbridge Wells; and in 1842, at Lowell, Mass., a joint special committee reported upon the numerous cases which had occurred in that city as a result of using lead services with ground water. In 1848,§ Louis Philippe and his family established themselves on the estate of Claremont in England. For thirty-three years this estate had been supplied through a leaden pipe from an open spring

* Of Weston & Sampson, Consulting Engineers.

† De Compositione Medicamentorum, Secundum Locos, Vol. XII.

‡ De Architectura, Liber VIII, Cap. 6, "De Ductionibus Aquarium."

§ Sedgwick — Journal N. E. W. W. Assn., XV, 316.

of great purity, two miles away. No bad results had been noticed by previous occupants, but 34 per cent. of the newcomers, including Louis Philippe and members of his suite and servants, suffered severely from lead poisoning. It was found upon investigation that, just prior to the coming of the French occupants, the spring, previously open, had been covered with an iron dome, thereby preventing the escape of the excess of carbon dioxide gas, and thus favoring the solution of the lead from the long pipe line which conveyed the water to the residence.

In 1848, when the introduction of the Cochituate water into Boston was under discussion, Professor Hosford,* of Harvard College, made a series of experiments and concluded that lead pipes could be used with safety for the conduction of this water. He found that although some corrosive action occurred when the pipe was new, a coating would soon be formed, which would be to such a great degree insoluble and impenetrable, that after a short time the action of the water would be practically nothing.

In 1870, Report of the Massachusetts Board of Health, it was stated 170 correspondents of the Board, in as many different places, reported 41 cases of either lead colic or lead paralysis. Most of these were explained by the drinking of well or spring waters drawn through lead pipe.

In 1871, in the second report of the Massachusetts State Board of Health, there is an interesting treatise on the general subject, including an experimental study into the effect of various waters on lead, by Prof. William Ripley Nichols, then associate professor of chemistry at the Massachusetts Institute of Technology. Professor Nichols felt justified in asserting that —

(1) The Cochituate water which has passed through lead pipes is never absolutely free from lead.

(2) That, when the water is first introduced into the pipes, there is more action on the pipes, as far as contamination of the water is concerned, than subsequently, but that after a few days' service the quantity of lead in the water is practically very small.

(3) That there is always more lead in the water after it has stood for some hours in the pipes than when it is allowed to flow freely.

(4) That when the water passes through a lead-lined tank it will be likely to contain in solution or suspension a more considerable quantity of lead salts, from the fact that the lead is corroded more rapidly on the sides of the tank at the surface of the water. Moreover, in such tanks there is generally a considerable extent of surface of contact between solder and the lead.

(5) That in the introduction of water into the pipes, the first effect is the tarnishing of the brightness of the lead due to the formation of oxide or suboxide; that there begins to form, almost immediately, a coating consisting on the *outside* of a brown and, at first, rather loose deposit (the color of which is not due to iron-rust as is ordinarily supposed, but to organic matter), and *underneath* of a white deposit composed mainly of

* Boston City Documents, 1848, Nos. 18 and 32. Also Proc. Am. Acad. II, 64.

carbonate of lead; that this coating increases with time in firmness and also in thickness, but that the rate of increase is so slow that practically the pipes used for conveying *cold* water do not wear out and become unserviceable, excepting from some accidental circumstance, as the freezing of the water; or, as is often the case where the pipes are laid under ground, from corrosion from the outside, or from a cause immediately to be mentioned. That, however, the pipes even under ordinary conditions would eventually wear out, I have no doubt, as there seems to be no limit to the action. I have, indeed, a specimen of a pipe which, being in contact with cold water only, for a period of fifteen years, was so corroded in the vicinity of the solder-joint as to be eaten through, and along the pipe there is a thick coating consisting almost entirely of carbonate of lead (with organic matter, a little carbonate and sulphate of lime, and a trace of oxide of iron) which has penetrated the pipe in some places to the depth of $\frac{1}{15}$ of an inch and more. There is one other circumstance contributing to the wear of cold-water pipes which is not to be overlooked. The water is delivered in many cases under such a pressure that the pipes tend continually to expand. The effect of this is often to strain the pipes so as to form longitudinal seams or grooves of greater or less length and, the corrosion taking place under such favoring circumstances more rapidly, sometimes extends through the pipe, which is thus rendered unserviceable by a combination of chemical and mechanical action.

(6) The pipes used to convey *hot* water are corroded more or less rapidly, a deposit similar to that in the cold-water pipes being formed, and the corrosion manifesting itself more decidedly in the vicinity of the solder points, and where the pipe is sharply bent. Whether the iron-rust, coming from the *water-backs* in which the water is heated, contributes to produce this effect, I am not prepared to say. The disarrangement of the particles of the lead and the change in its mechanical structure brought about by the alternate and unequal contractions and expansions to which it is subjected, must present more favorable opportunity for the corrosive action due simply to the passage of the water through the pipes.

Further study and modern physical chemistry have but explained the facts which this brilliant investigator established. Furthermore, his belief regarding the effect of the presence of various salts has been confirmed absolutely. One statement of Professor Nichols has a most familiar sound to the water-works man. It is: "The pipe in use is much inferior in strength and durability to that formerly in use."

During Professor Nichols's life, modern public-health engineering came into existence, and from then on more attention was paid to the poisonous effects of plumbo-solvent waters particularly in those regions where soft, peaty waters or waters containing much free carbon dioxide were in general use.

In the 1883 edition of Professor Nichols's *Water Supply* he describes experiments with various waters, using lead strips in some cases, and in one particular case a coil of $\frac{1}{4}$-in. lead pipe 100 ft. long. He makes the interesting statement that, "while in most waters the action on lead practically ceases, it probably never ceases absolutely."

Following Professor Nichols, the Massachusetts State Board of Health pursued its studies in this important field. In the report for 1886, a typical

case of lead poisoning is described, and its connection with a drinking water supplied through lead pipe was proved.

In 1898, Mr. H. W. Clark, chemist of the Board and a distinguished member of this Association, reported the results of his two years of exhaustive investigation. In Massachusetts, seventy-one, or 25 per cent., of the municipalities were supplied in whole or in part through lead (or lead-lined) services; in ten of these lead was used exclusively, and in fourteen others over 50 per cent. of the services were lead.

At that time, cases of lead poisoning were reported to exist in Fairhaven, Kingston, Lowell, and Milford, but the disease was not believed to have developed elsewhere. Exhaustive experiments by Mr. Clark showed that the waters supplying these four places dissolved more lead than the other waters experimented with. These four were ground waters, — clear, colorless, soft, nearly free from organic matter, — and contained oxygen and carbonic acid. Other ground and surface waters contained either too little oxygen and carbon dioxide to dissolve or erode lead, or so much organic or mineral matter that protective coatings were formed inside the service pipes.

In the 1900 report, Mr. Clark (with Fred B. Forbes) published additional results, which re-emphasize the importance of carbonic acid with or without oxygen in making waters plumbo-solvent.

In other states and in Great Britain, parallel studies had been carried on, particularly by Dr. A. C. Houston,* who examined numbers of waters which contained peaty acids and dissolved lead rapidly.

The report of the local government board for 1908 names forty-eight towns which are supplied with plumbo-solvent waters.

In Germany the subject received more or less attention. Spitta† states that certain cities are supplied with plumbo-solvent waters, *e.g.*, Dessau, Emden, Frankfurt, Kottbus, Offenbach, Oldenburg, and Wilhelmshaven.

In some of these, notably Dessau and Wilhelmshaven, lead poisoning had been very prevalent.

Causes of the Action of Water on Lead.

The causes of the action of water on lead may be deduced from the above descriptions of the works of Nichols and Clark. More recently they have been elucidated by Houston (*loc. cit.*) and this year with special reference to the Birmingham (England) supply by Liverseege & Knapp.‡ In 1910 the writer§ presented to this Association a theoretical discussion of the phenomena of corrosion of the metals used for service pipes.

Two distinct actions are now recognized: (1) Plumbo-solvency, or true solution; (2) erosion.

* Supplements to Reports of Local Government Board, 1900–1902.

† Arb. aus d. Kais. gesundhertsamb.

‡ Journ. S. C. I., *30*, 32 T.

§ Weston, The Corrosive Action of Water on Metals, this Journal, XXIV, 559.

Plumbo-Solvency.

By plumbo-solvency is meant the dissolving of the lead, — usually in carbonic or other acid. By erosion, a term introduced by Dr. Houston, is meant the action which a faintly alkaline or neutral water containing oxygen has on lead. Where erosion takes place, scales are formed on the surface of the metal. These scales fall off, leaving a fresh, bright surface open to attack. Lead so eroded imparts a turbidity to the water.

The cases cited above, where lead poisoning has occurred, were mostly those where the lead was truly dissolved in the water. Other cases are the soft, peaty water supplies as used in Northern England. Dr. Houston* states that out of 58 reservoirs examined, 35 yielded acid waters which were plumbo-solvent. Recent experiments by the writer with solutions of peat in distilled water have shown that this action is due to the peaty acids and not to some other agent. Moist, peaty soils are invariably acid, and the waters which drain from them are usually acid also. The acids in these waters have been manufactured in the peat by bacterial fermentation. The acid is not increased on storage. It decreases, but slowly, when the water is stored in a stoppered bottle. Exposed to the air, however, the peaty matter decomposes; the acids decrease, and are ultimately oxidized.

This action of peaty waters is quite rapid. My own experiments show that it is dependent upon the degree of color or the amount of peat.† Wm. Ackroyd‡ has shown that the plumbo-solvency of peaty waters varies with the acidity.

EFFECT OF ACIDITY ON PLUMBO-SOLVENCY.

Time, Hours.	Acid as H_2SO_4 (P.P.M.)	Lead Dissolved (P.P.M.)
1	2.9	0.3
1	3.0	0.57
1	2.9	0.25
0.25	13.4	7.1
0.25	15.9	9.5

Ackroyd does not distinguish between peaty acids and carbonic acid.

Clark (*loc. cit.*) showed that infusions of hay exerted little action on lead, but when the same had decomposed and produced carbon-dioxide gas, the action was rapid. The peaty acids, however, certainly dissolve lead. They may not be important constituents of hay infusions.

Another type of plumbo-solvent water is that which drains through certain rocks, particularly those containing pyrite or other compounds of sulphur.

The above, with the soft, spring, or well waters containing large amounts of carbon dioxide, are the three principal types of plumbo-solvent waters.

* Interim Report. Local Government Board, 1895.

† See page 247.

‡ J. S. C. I. (1899), p. 164, and (1900) p. 1130.

Erosion.

Certain soft waters, containing less than 30 p.p.m. of free carbon dioxide, which will not dissolve appreciable amounts of lead, produce erosion. Usually such waters have alkalinities of less than 15 p.p.m. If a bright piece of lead be exposed to a water of this type, contained in an open vessel, the whole surface of the lead is eroded, and a precipitate forms which falls to the bottom of the vessel, leaving the surface of the metal quite bright, but mottled.

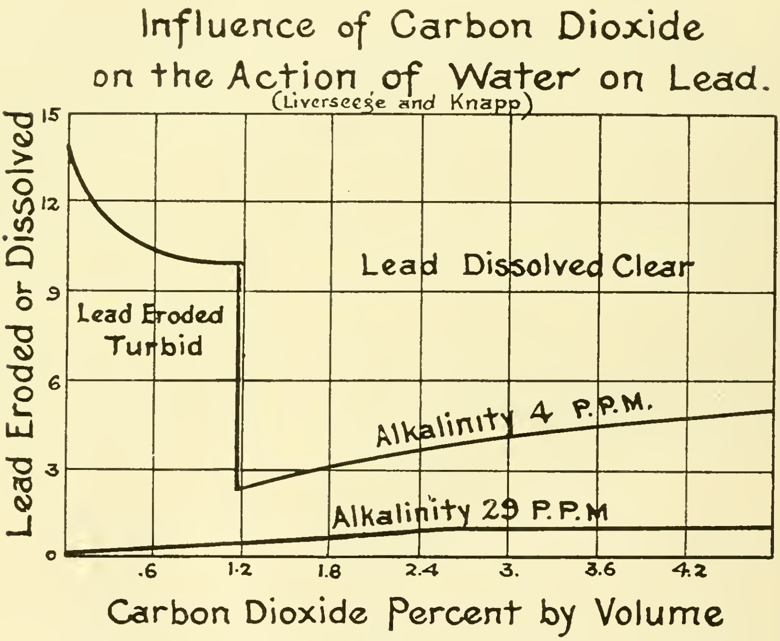

Fig. 1.

Waters of this group, which have an alkalinity of 15 to 25 p.p.m., rarely erode lead. Such waters do show some action on lead, but it is usually slight, and more or less crust is formed on the surface of the metal, usually on the upper surface of the pieces exposed. This crust usually consists of basic lead carbonate.

Waters of the same group, having an alkalinity higher than 25 p.p.m., usually produce a protective coating upon the surface of the metal, which prohibits further action of the water.

Erosion readily occurs in waters which contain no carbon dioxide and is due to the action of oxygen in the presence of water. Liverseege and Knapp (*loc. cit.*), state that an increase in the carbon dioxide from 1 per cent. to 2 per cent. by volume (from 20 to 40 p.p.m.) causes a sudden change from erosion to plumbo-solvency (Fig. 1). Erosion, therefore, is

largely due to the action of water and oxygen, and the degree of erosion is dependent more upon the degree of alkalinity of the water than any other factor.

Rideal* states that lead appears to be most soluble in waters containing oxygen and carbon dioxide in the ratio of 1 : 2.

In cases of peaty waters, the acidity to lacmoid, of the sample tested, usually determines whether or not the water will act on lead. With the reaction to lacmoid in view, waters may be divided into two classes: (1) Acid, plumbo-solvent, and non-erosive; (2) slightly alkaline or neutral, non-solvent, and erosive.

Acid waters are not necessarily those which contain no alkali in the form of carbonates. Plumbo-solvent waters which contain peaty acids or

FIG. 2. SHOWING PROTECTIVE COATING ON BOSTON SERVICE PIPE.

carbon dioxide may contain considerable alkali in the form of carbonates and still exert a solvent action upon lead. It all depends upon the relative potentialities of the acid and alkaline elements of the water. These factors will be discussed beyond under "Prevention of Action" (p. 248).

Fig. 2 illustrates the action of seven waters upon lead. One set of tubes shows the result of one, and the other set of seven days' action. Ten cubic centimeters of each sample were placed in open test tubes in which were afterwards placed pieces of bright sheet lead, about 1.0 in. by 0.5 in. by 0.2 in. (Area 10.1 sq. cm., or 1.57 sq. in.) This is the method of Dr. Houston as modified by Liverseege and Knapp.†

* Water Supply, 1915, p. 50.

† "*Method of Performing the Erosion Test.*" The method adopted in all experiments where the details are not specified is that outlined by Dr. Houston:

"Commercial sheet lead in strips ½-in. wide and about ⅛-in. thick (one square foot weighs 4.3 lb.) is scraped bright with a plumber's shave hook, and cut into lengths of 1 in. Each piece is rubbed with a

The waters used in the preparation of Fig. 2 were as follows:

	Characteristics.	Lead Found, P.P.M., after 7 Days.	1 Day.
Boston tap water	Soft, low-colored surface water	158	65
Distilled water	Nearly pure water	540	182
Still Poland water	Nearly pure spring water	82	44
Charged Poland water	Nearly pure spring water plus CO_2	154	90
Vichy (Célestins) water	Alkaline plus CO_2	32	10
Distilled water plus peat extract* — color 150	Peaty	41	6
Boston tap water with peat extract* added, color 150	Ditto plus some alkali	25	2

During the past few months, various waters have been tested according to Dr. Houston's method, with the results given in table on opposite page.

In the table it will be noted that erosion occurred only in those cases where the alkalinity of the water was low. Waters of the type of the Boston tap water erode considerable lead, but the further action of these waters upon lead surfaces is prevented by the formation of protective coatings. Waters like that from the well at Camden, which contain 199 p.p.m. of free carbon dioxide, fail to attack lead appreciably because of their high alkalinity.

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clean duster kept for the purpose, and dropped into the water without touching with the fingers. Test tubes 6 in. by ¾ in., reserved for this purpose only, are washed with tap water and allowed to drain.

"Ten cubic centimeters of the water is poured from a cylinder into the test tube, and the strip of lead polished with a cloth and dropped into it. The lead is now totally immersed in the water. The tube is shaken to remove air-bubbles from the surface of the lead and allowed to stand in a cupboard for one, three, seven, or fourteen days.

"(a) *If there is no evidence of erosion*, the water is decanted into a 50 c.c. Nessler cylinder and the lead strip shaken with about 10 c.c. of distilled water, which is poured into the cylinder. The lead is then removed and the tube washed with 5 c.c. of dilute acetic acid (roughly decinormal) and with water until there is 50 c.c. in the cylinder.

"(b) *If erosion is doubtful*, the water is decanted into a 50 c.c. Nessler cylinder, the lead dropped into a funnel, and any eroded lead washed off with a jet of water into the cylinder. Dilute acetic acid is used as before.

"(c) *If there is evident erosion*, the turbid water is decanted into a 100 c.c. flask. The lead is shaken out into a funnel and washed with a jet of distilled water. Ten cubic centimeters of the dilute acetic acid is put into the tube and allowed to stand a short time before it is emptied into the flask. The tube is washed with more distilled water and the flask filled up to the mark. When the solution is quite clear, 50 c.c. or a smaller measured quantity is put into a Nessler cylinder and made up to 50 c.c.

"Comparison is made in 50 c.c. cylinders. Five cubic centimeters of the dilute acetic acid (or a quantity sufficient to make the amount present up to 5 c.c.) and 3 c.c. of saturated hydrogen sulphide solution are added to every cylinder. The color produced by the colloidal lead sulphide is matched by standards prepared at the same time. The standards are made with distilled water, except in the case of very dark waters, when it is advisable to include 10 c.c of the original water.

"The standard lead solution used is of such a strength that 1 c.c. = 0.0001 grm. Pb, and is prepared from a solution a hundred times its strength, which contains 1.831 grm. of lead acetate and 10 c.c. of N/1 acetic acid per 100 c.c. Standards may be increased by 0.1 or 0.2 c.c. of the lead solution after the hydrogen sulphide has been added, but these standards are not so reliable as those to which the hydrogen sulphide is added last."

* The peat extract was not fresh. For effect of fresh extract see following table.

TABLE SHOWING ACTIONS OF VARIOUS WATERS ON LEAD.
(Houston's Method.)

Source of Sample.	Reaction to Lacmoid.	Alkalinity. P.P.M.	Hardness. P.P.M.	Lead Found in Water. P.P.M.	Remarks.
Distilled water (laboratory)	Slightly acid	0	0	420	Erosion
Well	Slightly acid	28.5	31.6	131	No erosion.
Well	Slightly acid	29.1	44.6	18	
Well, Chatham, Mass.	Slightly acid	24.1	38.0	26	No erosion.
Well, Harvard, Mass.	Slightly acid	13.9	35.4	18	
Well, Camden, N. J.	Slightly acid	137.5	220.	8	Free CO_2, 191 p.p.m.
Well, aërated and filtered	Neutral	132.	210.	6	
Well, Hamilton, Mass.	Neutral	22.1	27.8	3	
Well, Newport, R. I.	Neutral	88.7	22.1	4	
Well, Plainfield, N. J.	Alkaline	50.4	57.2	11	
Spring, Waterbury, Conn.	Slightly acid	23.7	75.4	24	
Charles River, Milford	Slightly acid	7.9	11.1	32	
Milford Tap	Neutral	24.0	28.6	7	
Reservoir, Exeter, N. H.	Alkaline	24.1	27.0	6	
Reservoir, Exeter, N. H., filtered	Slightly acid	11.2	27.4	11	Mechanical filter effluent.
Reservoir, Mt. Holyoke College	Slightly acid	27.2	39.0	20	
Reservoir, Mt. Holyoke College, filtered	Slightly acid	14.1	39.0	29	Mechanical filter effluent
Tap, Stroudsburg, Pa.	Neutral	22.1	24.8	5	
McMichael's Creek, Pa.	Acid	14.6	20.5	3	Turbid water.
Peat extract in distilled water	Acid	....	....	550	Color, 25 p.p.m.
Peat extract in distilled water	Acid	....	....	700	Color, 50 p.p.m.
Peat extract in distilled water	Acid	....	....	900	Color, 100 p.p.m.
Peat extract in distilled water	Acid	....	....	1 110	Color, 150 p.p.m.
Peat extract in Boston tap water	Acid	....	....	90	Color, 25 p.p.m.
Peat extract in Boston tap water	Acid	....	....	160	Color, 50 p.p.m.
Peat extract in Boston tap water	Acid	....	....	170	Color, 100 p.p.m.
Peat extract in Boston tap water	Acid	....	....	210	Color, 150 p.p.m.
Boston tap water	Alkaline	12.1	19.2	113	Erosion.

Prevention of Action.

The action of water on lead is prevented in many cases by the formation of a protective coating of basic lead carbonate, of silica, of organic matter, or of other substances deposited from the water. This coating adheres closely to the exposed surface of the pipe and practically prevents action. Nearly all waters may be made to form protective coatings by the addition of certain chemicals to them.

Natural Protection.

The formation of a protective coating is best illustrated by the following experiment:

A test piece of lead was placed successively in 10 c.c. portions of Boston tap water, and in each case allowed to stand seven days before changing the water. The water was changed twice, and the lead determined in each successive portion with the following results:

Experiment to Demonstrate the Formation of Protective Coating.

Test No.	Age of Surface, Days.	Lead Eroded, P.P.M.
1	7	110
2	14	42
3	21	26

Prof. William P. Mason* found the following amounts of metal in city rain water which had been stored three and a half months in contact with old and new lead surfaces, respectively:

Old lead	3.65 p.p.m.
New lead	58.10 p.p.m.

The experiments demonstrate why old lead surfaces may be used for conveying certain waters which actively attack clean, new pipe.

Fig. 3 shows the coating formed on the lead services at Concord, Mass., from a pond water; also shows a specimen of the Concord pipe after the coating has dried. Fig. 2 shows a specimen of service pipe, recently removed from the Boston works. (Fig. 3.)

Certain waters which contain no organic matter also form protective coatings on lead. These waters are either alkaline, or deposit carbonates, sulphates, silica, or silicates on the surface of the lead. Basic carbonate of lead deposits from certain waters, and is a great protection. Its solubility† is equivalent to 1.3 parts of lead per million of pure water.

Artificial Protection.

Dr. Houston (*loc. cit.*) showed that the addition of small amounts of sodium carbonate prevented the action due to peaty waters, and that

* Water Supply, p. 461.

† Pleissner (1907).

only small amounts of this chemical were required to coat the metal with an adherent film. Calcium carbonate and bicarbonate also inhibit erosion, but relatively large amounts of lime (calcium hydrate) are required to produce equivalent results.

Liverseege and Knapp (*loc. cit.*) have made careful experiments to determine the best chemicals to prevent erosion of lead by the Caban Reservoir water (Elan Valley, Wales). This water is alkaline to lacmoid,

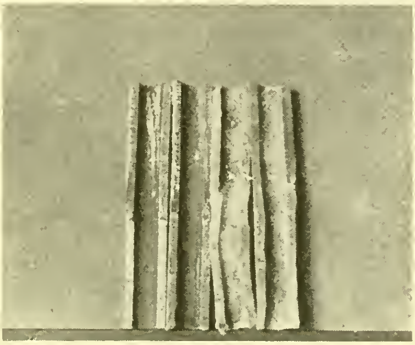

FIG. 3. SHOWING COATINGS ON CONCORD (MASS.) SERVICE PIPE.

and has an alkalinity of only 3 p.p.m. Its action on lead, therefore, is not due to peaty acids. Calcium carbonate (chalk) is the chemical added. The results of their experiments are given in Fig. 4.

They also found that as little as five parts of potassium permanganate per million were sufficient to form a protective coating and prevent erosion.

The practice of adding calcium carbonate in the form of powdered chalk to very soft peaty waters has been common in England for very many years, and the results have been satisfactory. Descriptions of this process as applied in practice have been given by Houston (*loc. cit.*), Marsh,* McCauley,† and others. Among the important cities where the treatment is applied are Sheffield, Wakefield, and Bradford, England. Prof. George C. Whipple‡ and others have discussed before this Association the removal of the corrosive properties of water by "decarbonation," or, to use the term which the writer prefers, by "neutralization."

While this paper has to do with the practice rather than the theory of prevention, it may be stated in brief that prevention of corrosion consists in neutralizing the acid components of the water by the addition of

* Notes on the Sheffield Water Supply, L. S. M. Marsh, Proc. Inst. C. E., Vol. *CLXXXI*, Session 1909–1910.

† Same Journal, *CLXXXI*, 8.

‡ JOURNAL, *XXVII*, 193 and 445. "Decarbonation as a means of removing the corrosive properties of public water supplies."

certain alkalies, or, to state the problem in scientific terms, to neutralize the effect of the hydrogen (H) ions by the introduction of hydroxyl (OH), carbonate (CO_3), or bicarbonate (HCO_3) ions.

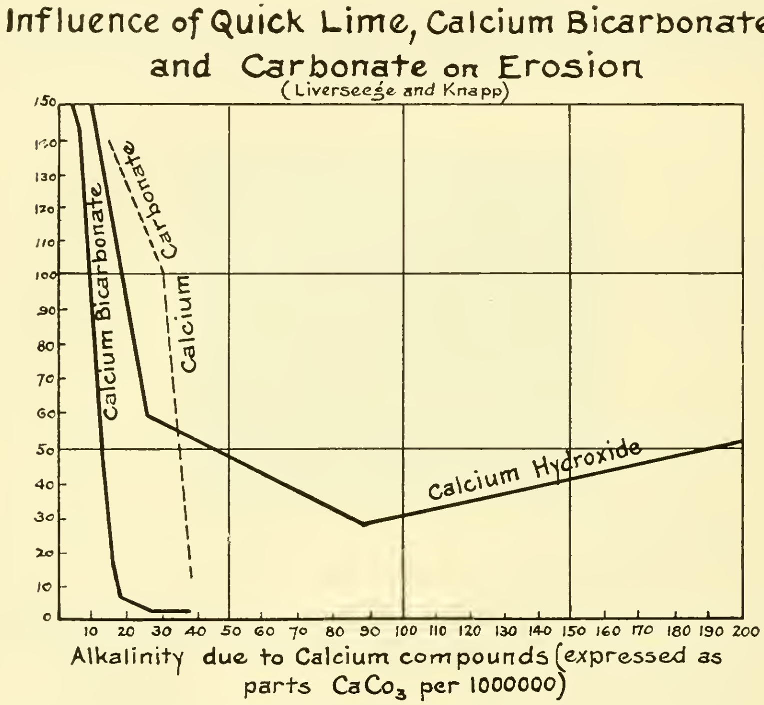

FIG. 4.

This theory reduces itself in practice to the following:

Kind of Water.	Best Chemical for Treatment.
Surface waters which are acid to lacmoid, are soft and contain oxygen	Chalk ($CaCO_3$)
Surface waters which are soft and contain both oxygen and high carbon dioxide	Lime (CaO)
Ground waters of low alkalinity, containing relatively small amounts of carbon dioxide	Chalk or lime
Ground waters of high alkalinity, containing large amounts of carbon dioxide	Lime

Waters containing large amounts of carbon dioxide and of high alkalinity are improved by aëration, while the reverse is true when the waters are of low alkalinity and soft.*

* See page 247.

Experiences at Milford and Hopedale.

The first water supply of Milford, Mass., and the adjoining town of Hopedale was taken from three wells along the bank of the Charles River at a point just above Milford. Most of the services in the original works, built in 1881, were of lead. As cited above, alleged cases of lead poisoning occurred during the early years of operation, with the result that in 1903 the company built slow sand filters, and thereafter the consumers were largely supplied with filtered water from the Charles River, in place of water from the wells. Following the placing of the filters in service, the cases of lead poisoning disappeared, and until 1914 the company believed that it had done everything necessary to protect its consumers. In that year, however, one suspicious case of illness occurred, and while the patient was unusually sensitive, the water used was drawn through the long service pipe supplying the patient's house. An examination of the filter and its product indicated that between January, 1904, and June, 1914, when the tests were made, a large amount of organic matter derived from the colored Charles River water had been gradually stored in the sand. This was demonstrated by analyses of samples of sand collected from the surface and from a point six inches below the surface of the filter. The results of analysis were as follows:

Point of Sampling.	Loss on Ignition.	Albuminoid Ammonia.
Surface	0.58 per cent.	81 p.p.m.
6 in. below surface	0.51 per cent.	63 p.p.m.

The organic matter fermented and produced carbon dioxide. This was shown by twenty-four-hourly determinations of carbon dioxide and oxygen, in the influent and effluent of the Milford Water Company's filter. The results were as follows:

	Parts per Million.					
	Carbon Dioxide.			Dissolved Oxygen.		
Source of Sample.	Av.	Max.	Min.	Av.	Max.	Min.
Charles River	7.15	8.5	6.2	8.32	8.73	7.89
Filter effluent	15.1	16.8	13.5	5.77	6.49	5.02

It was therefore concluded that the causes of the corrosion of the service pipes were an excessive amount of carbon dioxide, the presence of oxygen, also low hardness and alkalinity. The average results of chemical analyses of the water are appended.

Experiments were begun immediately to determine what chemicals would be most effective to counteract the erosive action of the water.

Experiments.

Experiments were made by exposing 8-in. pieces of ½-in. lead pipe, all from the same coil, each piece of the same weight, to samples of Milford water before and after aëration, and with and without the addition of certain protective chemicals. For a control, the action of Milford water was

compared with that of Boston Metropolitan water drawn from the tap in the writer's laboratory. Experiments were conducted in sealed bottles and under conditions uniform for all samples tested. The results are given in the following table:

RESULTS OF EXPERIMENTS TO DETERMINE THE AMOUNT AND KIND OF CHEMICAL NECESSARY TO ADD TO MILFORD WATER TO PREVENT ITS CORROSIVE ACTION UPON LEAD PIPE.

Number and Description.	Lead Dissolved in Six Days. Parts per Million. First Experiment, June 11.	Second Experiment, June 30.
1. Milford water	27.0	9.5
2. Milford water, aërated	84.0	54.5
3. Metropolitan water	108.0	129.0
4. Milford water plus 15 p.p.m. chalk	10.0	14.0
5. Milford water aërated, then 15 p.p.m. chalk added	16.0	13.0
6. Milford water plus 15 p.p.m. chalk, then aërated,	12.0	17.0
7. Milford water plus 15 p.p.m. magnesia, then aërated	10.0	....
8. Milford water aërated, then 8.5 p.p.m. quick lime added	....	22.5
9. Milford water plus 8.5 p.p.m. quick lime	....	1.1
10. Milford water plus 12 p.p.m. quick lime, then aërated	....	1.4
11. Milford water plus 20 p.p.m. quick lime, then aërated	....	1.35

The characteristics of the waters used for the experiments are shown in the following table:

CHARACTERISTICS OF SAMPLES TESTED.

	Parts per Million. First Experiment.	Second Experiment.
Carbon dioxide, Milford water	9.8	11.3
Alkalinity, Milford water	7.1	7.0
Hardness, Milford water	11.9	11.9
Total solids, Milford water	38.0	39.0
Carbon dioxide, Milford water after aëration	5.2	4.2
Carbon dioxide, Metropolitan water	3.1	2.9
Alkalinity, Metropolitan water	8.5	8.4
Hardness, Metropolitan water	18.5	18.5
Total solids, Metropolitan water	39.0	40.0

The dissolved oxygen was not determined, as all samples were unavoidably exposed to the air in the laboratory.

The above results were remarkable and somewhat surprising, and from them it was concluded:

1. The aëration of the Milford water is a decided disadvantage, as may be seen by comparing tests Nos. 2 and 8 with Nos. 1 and 9. The reason for this increased action is that the oxygen precipitates the lead previously dissolved by the carbon dioxide, thereby setting free an equiva-

lent amount of carbon dioxide to re-attack the lead pipe, and so on until not only is the carbon dioxide used up, but the oxygen as well. In other words, the plumbo-solvent action of this water can be measured, not only by the amount of carbon dioxide, but also by the amount of oxygen, and at present it combines the disadvantages of a ground water containing carbon dioxide with those of a filtered surface water containing oxygen as well as carbon dioxide.

2. The addition of 15 parts of chalk or magnesia per million of the water greatly reduces the solvent action of the water. The reduction is less when the water is aërated.

3. The addition of 8.5 parts of quick lime, which is equivalent to 15 parts of chalk, reduces the action of the unaërated water on lead to practically nothing, only 1.1 parts of lead being dissolved after six days' contact. The reason for the increased action of the lime as compared with chalk is that the lime combines directly with the carbon dioxide, thereby taking it out of action.

4. By increasing the amount of lime, the corrosive action of the water can be prevented, even though aërated.

As a result of the experiments, the writer recommended that the water be treated with from 8 to 10 parts of quicklime per million, equivalent to from 85 to 100 lb. of high-grade commercial lime per million gallons.

The recommendation was adopted by the company. In 1914 the neutralizing plant was built, and in December of that year put into service. The plant consisted of the following parts:

1. Storehouse for lime.
2. Tanks for making milk-of-lime.
3. Pumps for circulating the milk-of-lime through the apparatus for regulating the application of lime.
4. Feed regulator.
5. Tank for separating the lime from the sand and other insoluble matter.
6. Feed box with ball cock to prevent the entrance of air into the suction with the lime water.
7. Pitot tubes and manometers for measuring the rate of flow through the pumps.
8. Meters for measuring the water used to dissolve the lime and drive the Pelton wheel.
9. Pelton wheel to drive mixers and pump; water to be returned to well. This was by far the cheapest source of power.
10. Shafting, piping, belting, scales, wheelbarrow, etc.
11. House for apparatus.

The arrangement of the plant is shown in Fig. 5.

These devices were installed and the plant placed in operation in

December, 1914. The good results of treatment were apparent at once. A laboratory test, employing the method used in the writer's previous experiments,* gave the following results:

Source of Sample.	Lead Dissolved from Service. P.P.M.
Filter effluent untreated	5.8
Filter effluent lime-treated	1.55

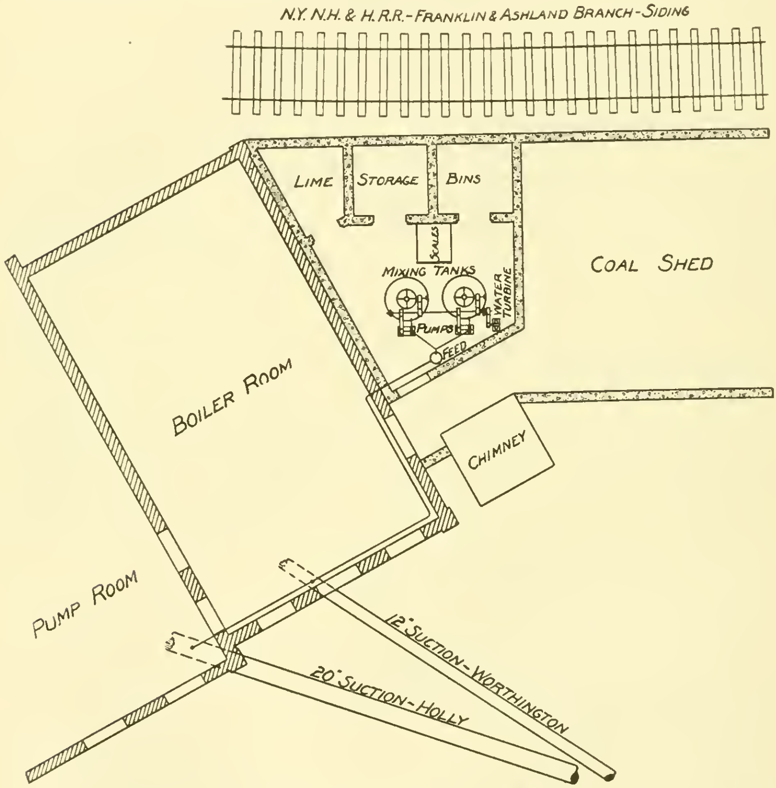

FIG. 5. PLAN OF NEUTRALIZING PLANT OF MILFORD WATER COMPANY.

On December 14, determinations of the dissolved oxygen and carbon dioxide in samples taken from various points in the system gave the results shown in the following table:

RESULTS OF GAS DETERMINATIONS AT MILFORD.
December 14, 1914.

Source of Sample.	Parts per Million. Dissolved Oxygen.	Parts per Million. Carbon Dioxide.
Charles River water	9.23	2.4
Filter effluent	8.35	7.6
Well No. 2	2.94	17.4
Well No. 3	6.43	12.8
Lime-treated water in pumping station	11.82	0.0
Lime-treated water from tap, 16 West Pine Street,	11.92	0.0

* See page 252.

Tests for the presence of lead in the treated water, from a tap in the city under conditions of ordinary use, and after standing in the service over night, respectively, are given in the following table, in which are also given the results of similar tests of samples collected on September 21, before the plant was put in operation.

Date, 1914.	Lead, Parts per Million. Ordinary Use.	After Standing in Service Overnight.
September 21	0.27	2.63
December 14	0.063	0.183

The above indicates a reduction of 79 per cent. in the erosive action of the water under conditions of ordinary use, and of 93 per cent. after standing in the service pipe overnight. Later results show even higher reductions.

Results in Practice.

Since December, 1914, monthly samples have been collected from a tap under conditions of ordinary use and after standing overnight in the lead service, respectively. The annual average results under conditions of ordinary use are as follows:

ANNUAL AVERAGE RESULTS OF ANALYSES.
(Parts per Million.)

Year.	Hardness.	Free Carbon Dioxide.	Lead. Average.	Maximum.	Minimum.	Average Lime Added.
1914	13.0	18.6	0.27	2.63	...	0.0
1915	30.0	0.30	0.124	0.15	0.12	12.9
1916	24.0	0.25	0.10	0.11	0.10	12.1
1917	34.9	0.40	0.09	0.10	0.08	11.4
1918	31.8	0.23	0.082	0.11	0.07	11.1
1919	36.7	1.40	0.085	0.10	0.07	10.0

It will be noted that the action of the water on the lead decreased from 1915 to 1918. It was slightly higher in 1919, due to the fact that the dose of lime was purposely decreased, as was indicated by the increase in free carbon dioxide. On an average, the Milford-Hopedale water requires a dose of about 11 parts of commercial quicklime per million, equivalent to less than 10 parts of calcium oxide (CaO).

At the present time the plant is being operated so as to keep below 0.1 p.p.m. the amount of lead found in the water under conditions of ordinary use.

The following diagram (Fig. 6) illustrates the differences between the average amounts of lead found in the water under conditions of ordinary use and after standing in the service pipe overnight, respectively.

Protection by Filtration.

Schmidt* showed that lead compounds are found in certain waters in a state of true or colloidal suspension, and may be removed therefrom by Berkefeld or similar filters. Following that suggestion, Schwenkenbecher

* Archiv. f. Hygiene, 1913, *80*, 70.

and Neisser* experimented with these filters attached to lead services, and were able to reduce the amount of lead in the water so supplied from as low as 0.7 and as high as 6.0 p.p.m. to 0.0, and to stop cases of poisoning caused by the unfiltered water.

These experiments have been repeated under the writer's direction, using a water supplied through a lead service, and employing two filters: one, a "Berkefeld" filter containing a tube formed of baked infusorial

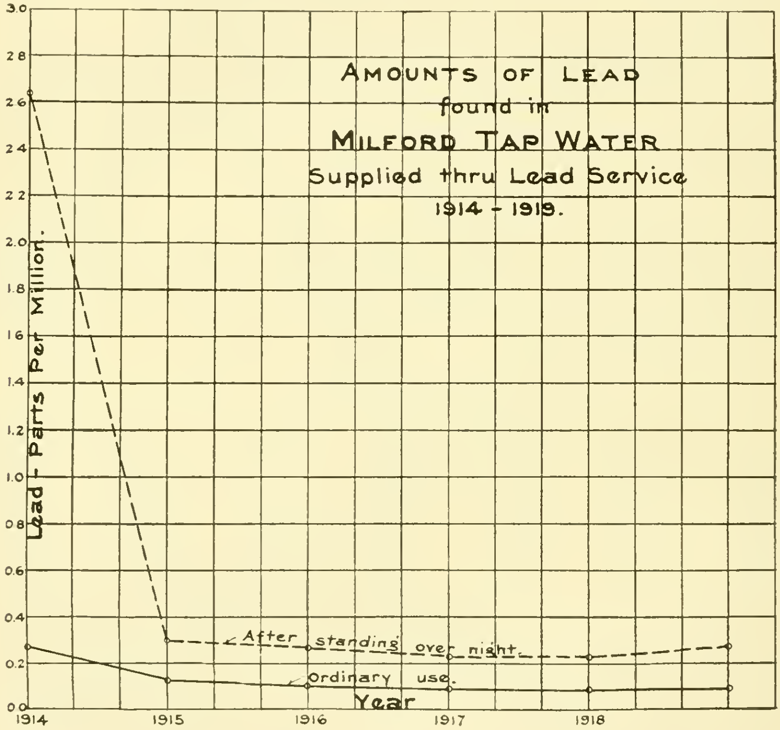

Fig. 6.

earth; and the other, a "Boston" filter containing tubes of unglazed porcelain. During four months of operation, samples were collected from each of these filters with the following results:

Results of Experiments with Household Tube Filters.

(Parts per Million.)

Date.	Unfiltered. Standing Overnight.	Unfiltered, Ordinary Use.	Berkefeld Filter Effluent.	Boston Filter Effluent.
January, 1920	0.28	0.08	....	0.06
February, 1920	0.30	0.09	0.05	....
March, 1920	0.28	0.09	....	0.07
April, 1920	0.29	0.08	0.05	....
Mean	0.29	0.085	0.05	0.065

* Munchener Med. Wochensch., 1914, *61*, 352: Gesundheitsingenieur, 1913, No. 51.

These experiments show that household filters may be depended upon to remove from the water those compounds of lead which are dislodged from the service pipe during periods of standing and are present in the water first drawn; these are, of course, the most dangerous. They do not greatly reduce the amounts of lead found in water drawn under conditions of ordinary use, and seem hardly worth while where care is taken to empty the service pipe before using the water for drinking. They are an offset to carelessness, and as such are sometimes advisable, although they are usually ill-cared for and become brood chambers for bacteria.

The Toxic Action of Lead in Water.

Lead is a cumulative poison. Its usual and well-known manifestations are anemia, cachexia, blue line around the gums, colic, wrist-drop, contracted kidney, etc. It is possible, however, to have evidences of absorption of lead without the usual symptoms of lead poisoning. These may consist of the presence of lead in the urine (especially after the administration of potassium iodide), blood changes, and the tendency of women to have miscarriages.

Prof. Reid Hunt, of the Department of Pharmacology of the Harvard University Medical School, has been consulted, and has reported cases in which a considerable number of persons were poisoned by drinking water containing the following amounts of lead:

Lead, P.P.M.	Place.
0.5 — 1.6	At Sprokhoevel (in Westphalia), (Lemmer).
0.7 — 12.5	At a village in the Taunus (Schwenkenbecher and Neisser).
0.998 — 9.983	At Sheffield (White and Allen).
1.997	At Huddersfield (Aird).
1.143 — 11.98	At Huddersfield (Stevenson).
1.43 — 4.28	At Manchester (Calvert).
2.00 — 15.00	At Castle Claremont (de Mussy).
8.7	At Keighley (Stevenson).

Amounts which a number of writers have stated to be poisonous or tolerated are as follows:

Lead, P.P.M.
0.36 *may* be poisonous (A. Smith).
1.41 may not be poisonous (A. Smith).
0.36 maximum permissible amount (Rubner).
0.3 or, at most, 0.5 permissible (Schwenkenbecher and Neisser).
0.7 maximum permissible amount (Steiner).
0.71 tolerated (J. Smith).
1.00 tolerated (Gärtner) (Telekey).
1.43 tolerated (?) (White).

At Dessau there were many cases of poisoning when the water contained 4.14 p.p.m. The lead was reduced to 0–0.5 p.p.m. and no case of poisoning was reported during the following ten years. On the other hand, certain French hygienists have reported isolated cases of poisoning from

0.1 p.p.m., and it is stated that soda water containing 0.32 p.p.m. has caused poisoning, and 0.8 p.p.m., death.

Thresh, "Examination of Water," states that he has noted cases of lead poisoning with waters varying from 0.14 to 1.4 parts of lead per million.

It would seem from the above that water containing less than 0.1 part of lead per million would, when judged by practical standards, be considered safe, and the recent experience at Milford supports this opinion.

It is apparent that there is no proof that drinking waters containing 0.1 part of lead per million, or even more, cause disease. This lack of proof may be due to imperfect methods of medical diagnosis.

Practical Considerations.

It is obvious, of course, that the action on lead of any water under consideration as a new source of supply should be known before the metal for services is chosen. Managers of works already in operation with lead services should certainly inform themselves regarding their own conditions, and if their water be found to attack lead to any appreciable degree, they should take steps to prevent or minimize its effect.

Waters which attack lead will usually attack iron, — both plain and galvanized, — also steel. Consequently, the action of such may be prevented best by the use of cement-lined services. Many water works, however, have thousands of dollars invested in lead services. If the water supplying such works be found to attack lead services, the best plan is to replace them gradually, using cement-lined iron pipe, meanwhile protecting consumers by the proper treatment of the water supplied through the existing lead services. This course has been followed by the Milford Water Company with gratifying results.

Acknowledgments.

The writer wishes to thank the Engineering Department of the State Department of Health for analytical data; Messrs. McInnes and Robinson for specimens of pipe; Mr. A. L. Gammage, of Weston & Sampson's laboratory, who has made most of the determinations of lead; and especially Mr. Frank J. Dutcher, treasurer, and Mr. J. W. Kay, superintendent, of the Milford Water Company, for their broad-minded and full coöperation during several interesting years.

Some Additional References.

Hippocrates, "Ancient Medicine," about B.C. 400. (Littré's translation, 1861.)

Pliny, "Historica Naturalis," about A.D. 50.

H. Heap, "Study of the Action of Various Waters on Lead," Journ. Soc. Chem. Ind., *32*, 771.

Gaertner, Vierteljahrschrift fuer ges. Med. und oeff. Sanit. (1910), *40*, 104.

Legge and Goadby, "Lead Poisoning and Lead Absorption," 1912.

Lehmann, "Action de l'Eau sur les Tuyaux de Zinc." "La Technique Sanitaire," Sept., 1913.

Ebner, "Ueber die Löslichkeit von Blei in bleiernen Wasserleitungsrohren." Inaugural Dissertation, Würtzburg, 1897.

Paul, Ohlmüller, Heiser v. Auerbach, Arb.a.d. Kaiserl. Gesundeitsamt (1906), *23*, 333.

Harrington, "Practical Hygiene," 344 *et seq.*

MILFORD-HOPEDALE SUPPLY.*

Average Results of Analyses.
(Parts in 1 000 000.)

Source.	Date.	Color.	Oxygen Consumed.	Nitrogen as Free Ammonia.	Nitrogen as Albuminoid Ammonia. Total.	Nitrogen as Nitrates.	Nitrogen as Nitrates.	Chlorine.	Hardness by Soap.	Alkalinity.	Residue on Evaporation. Total.	Iron.	Free Carbon Dioxide.	Lead, Ordinary Use Av.	Lead, Ordinary Use Max.	Lead, Ordinary Use Min.
Wells..........	1887–02	12.5	1.95	.007	.076	.0005	.223	2.67	12.66	...	39.80	.131	...	...	...	...
Tap..........	1888–03	6.4	2.70	.002	.045	.00075	.191	2.80	10.66	...	33.52	.153	...	1.39	9.40	0.167
Charles River..	1887–00	64.3	6.69	.015	.218	.0000	.091	2.50	5.00	...	34.00	...	...	...	...	...
Charles River†.	1905–14	19.8	2.75	.0116	.147	.0001	.121	3.46	11.33	...	38.22	.138	18.6	0.27	2.63	...
Charles River‡.	1915	28.0	2.5	.013	.087	.0000	.064	3.80	30.00	25.0	65.60	.210	0.[illegible]0	0.12	0.15	0.12
Charles River..	1916	23.0	...	.007	.062	.0000	...	3.60	24.00	29.6	55.70	.180	0.25	0.10	0.11	0.10
Charles River..	1917	20.0	...	.025	.089	...	...	4.00	34.90	29.4	53.30	.24	0.40	0.09	0.10	0.08
Charles River..	1918	20.0	...	.011	.069	...	...	3.70	31.80	27.9	63.70	.27	0.23	0.08	0.11	0.07
Charles River..	1919	22.0	...	.008	.072	...	...	3.40	24.00	27.5	...	.31	1.40	0.09	0.10	0.07

* By Mass. State Department of Health and Weston & Sampson.
† Taken from tap after being filtered.
‡ Filtered and treated.

Discussion.

Charles D. Howard.* In New Hampshire, we have for many years been fighting the lead pipe proposition. The attitude of our Board is that lead and its salts are definitely recognized as active poisons, and that the use of this material as a water conductor is to be deemed as unsafe and therefore as something to be uniformly avoided.

For some years practically no private installations using lead pipe have been made, while, as for the public water systems, any plans or specifications calling for this variety of pipe would fail to receive the approval of our board as required by law.

With all samples, representing both public and private sources, where-ever there is a record of lead pipe in use, it is our practice to quantitatively estimate the proportion of lead present. Formerly up to 0.05 parts per hundred thousand was regarded as "safe." At present we find this "safe" limit lowered to 0.025 parts. As a matter of fact, I do not believe we are justified in considering any determinable amount of lead as "safe" under any and all circumstances. It is not alone that the susceptibility of the individual differs, but also that the amount of this metal, as occurring in the dissolved or suspended condition in water will vary, being governed by a variety of changing conditions.

It is realized that the expense of replacing a lead system already existent would be very material, and for this reason there is, undoubtedly, justification for adopting the alternative plan of chemical treatment. I further realize that there are lead pipe systems in use which apparently are not or never have given trouble. Nevertheless, the water-works manager who, in the light of present-day knowledge of the subject, deliberately installs a pipe system of this variety, is doing a most unwise thing.

Stephen DeM. Gage.† I have listened with much pleasure to Mr. Weston's excellent paper, because it deals with one phase of the public water-supply problem in which I have been especially interested for some time.

Mr. Weston has mentioned the 1898 report of the Massachusetts State Board of Health on Lead Poisoning and the studies of Mr. Clark on the action of water on lead published in that report. In some manner a great many people have obtained the impression that these Massachusetts reports are authority for the assumption that surface waters do not attack lead, and that unless there is at least one-half part of lead per million in a water it is not likely to be dangerous to health. This is entirely a misconception, and I am glad to have the opportunity to correct it. In the general report of the Massachusetts Board for 1898 it is stated:

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* Chemist, New Hampshire State Board of Health.

† Chemist and Sanitary Engineer, State Board of Health of Rhode Island.

"*The exact amount of lead which may be taken into the system without producing harm is not definitely known and may vary with different people, but it is known that the continuous use of water containing quantities of lead as small as .05 part per 100 000 has caused serious injury to health.*"

On page 569 of the same report Mr. Clark says:

"*Interviews with physicians in the cities and towns where series of samples were taken fail to show a prevalence of lead poisoning in any except the four places mentioned above, although occasional cases have been noted in several other towns that have ground-water supplies. Our investigations so far made in the towns and cities having surface-water supplies have failed to reveal any cases whatever, although many of these waters attack lead, and the lead taken in this manner into the systems of many of the inhabitants may cause mild or unrecognized cases of lead poisoning.*"

These are clear statements of the belief existing at that time that very small amounts of lead might be harmful to some people, that there might be unrecognized cases of mild lead poisoning, and that surface waters would absorb lead in greater or less degree.

During the past few years more attention has been paid to obscure causes of minor ailments, and incidentally much has been learned about lead poisoning.

While we are in the same position to-day as we were twenty years ago as regards definite knowledge as to the exact amount of lead which may be taken into the system without producing harm, we do know definitely that some people are so sensitive that they are unfavorably affected by the presence of very minute quantities of lead in their food or drinking water.

It was my good fortune to be associated with Mr. Clark at the time these investigations were in progress and for some years afterward, and while our time was largely taken up with more urgent problems, every once in a while the thought would come that there was a whole lot we didn't know about lead poisoning. When I went to Rhode Island in 1914 I found that not only was the use of lead for services almost universal, but a very large proportion of the houses were piped with lead. I looked up the mortality records and questioned a good many physicians, and, so far as I could learn, lead poisoning — that is to say, chronic lead poisoning — was practically unknown in the state.

In 1915, or early in 1916, my interest in the subject was again aroused by two instances of lead poisoning which had gone unrecognized for some time. One of these was the case of a middle-aged physician who had retired from active practice because of ill-health of both himself and his wife. In some manner he was led to suspect his water supply and asked us for assistance. On investigation we found that he was using water from an excellent spring brought into the house through lead pipe. Analysis of the water showed lead present in small amounts, about .2 part per mil-

lion, as I remember it. We advised him that while this amount of lead was not usually considered dangerous, it was quite possible that he might have an idiocyncrasy for lead, and that it would do no harm if he changed his drinking water to one which could not possibly have any lead. This he did and in a few months both he and his wife regained their health and he was able to resume practice. He later wrote us a letter of appreciation in which he stated that both he and his wife had believed that they were doomed to a premature old age until we had shown them the path back to health.

Another and even more illuminating instance is that of a small isolated community of eight or ten families. If I remember correctly, all but one of these families obtained their water through lead pipe from springs on the side of a hill. Practically every member of these families was afflicted with what they called rheumatism, one old couple being practically bed-ridden. One house was so situated that the spring supply was not available, and this family obtained their drinking water from a well with a bucket and chain. This family were free from rheumatism. One doctor after another had been called to treat the rheumatic sufferers without avail. Finally a physician was called who had heard about the previous case, and as a last resort asked us to look into the lead question. Our investigations showed considerable amounts of lead present in the water as delivered at each of these houses, and upon our advice the lead pipe was removed and other material substituted. In the course of a few months rheumatism practically disappeared from that community.

Since then I have talked lead poisoning to physicians and waterworks officials in our state until some of the latter undoubtedly think I am a crank on the subject. We have not had the time or the funds to make a thorough lead survey of all our water supplies. In fact, unless such a survey was exhaustive, it might show very misleading results, for the reason that, in our experience, lead solvency may vary widely in two adjacent services on the same water supply. We are, however, getting at the facts in another way by helping the physicians to detect the mild cases and thus build up a record of their prevalence. In Rhode Island we do something which I think is not done by any other state in the Union, that is, we make any kind of a test or analysis which will help a physician to form a correct diagnosis of any disease. A good many of the doctors have formed the habit of coming in to talk over their doubtful cases and see if there isn't something we can do to help them find out what is the source of the ailment. Oftentimes one or more of the symptoms is suspicious, and we suggest comparative tests for lead on the urine and on the drinking water. In this way we find now a case here, now one there. Hardly a month goes by but we make one or two additions to the list. Obscure cases, indigestion, chronic constipation, kidney trouble, rheumatism, and other ailments which do not yield to treatment may be only lead poisoning masquerading under one of its many aliases.

The more I study the subject the more convinced I am that lead poisoning is a contributory cause of more or less sickness in practically every community where lead is used for conveying drinking water. If this be true, then a good many of our public water-supply officials will have to face a big problem. Treatment of the water will undoubtedly greatly reduce its plumbo-solvent action and thus lower the incidence of lead poisoning, but it is extremely doubtful if any treatment can be made so thoroughly efficient that it will eliminate all chance of the water containing lead some of the time. It begins to look very much as though the day of the lead pipe for water-supply purposes was doomed, and that eventually the lead services already in would have to be replaced by some other material. Certainly no water-works official would care to take the responsibility of continuing to use lead with the chance that it might seriously affect the health of even a small proportion of his consumers.

Mr. A. O. Doane.* I should like to inquire whether anybody has made any experiments or has any data about the effects of lead in paints upon water tanks. We have made some studies that showed that when red-lead paint was used; — in tank experiments where the proportion of painted surface to volume of water was very much more, probably eight or ten times as much as in the standpipe, — the lead found in the water was not above the safe limit. We made the experiments by painting plates of steel with the same lead pigment that we intended to use in the standpipe. We put them in a crock, and allowed them to stand under water for some weeks. The water in the crock was then examined by the State Board of Health and they gave us a clean bill of health on it, reporting that the water did not take up, even in the concentrated form, a dangerous amount of lead — I think it was less than eight-tenths in a million.

Mr. Weston. I am familiar with this subject, but have never seen a case of poisoning by red lead. In the first place, red-lead pigment is mechanically mixed with linseed oil, which makes an envelope around the pigment; and then there is a coating, on top of that, of various substances out of the water; so you would take no chances of injury from this source.

Mr. Doane. It does not seem to make any trouble, and in my opinion red-lead pigments are the best things to resist water, so that it is quite an important point in the painting of standpipes.

* Division Engineer, Metropolitan Water Board, Boston, Mass.

THE RELATION BETWEEN OFFICE METHODS, REGULATIONS, AND THE WATER CONSUMER.

REEVES J. NEWSOM.*

[*September 9, 1920.*]

Water consumers, as a class, are peaceful, law abiding, and willing enough to comply with the rules of the department when informed of their existence, but there is always in every community a certain small percentage who keep the water-works officials on the jump, and because of whom it becomes necessary to bind all consumers to a contract and with regulations which are as near air-tight as it is possible to make them.

These consumers are mainly of three kinds, — the one who feels that because he pays taxes or is a life-long resident he should get his water service free; the one who has some brilliant idea of how his case can be handled so that it will be a few dollars less expensive, irrespective of the precedents or standards which he would upset; and the all-around trouble maker who will not sign a contract or pay a bill until he is forced to, who threatens all sorts of dire things if his water is shut off, and who is continually looking for an opportunity to collect for damages of some kind from failure in some feature of the service.

The new consumer, when he applies for water in Lynn, is presented with a card form of contract which he is required to sign, and when he does so he has practically forfeited all his rights, as the contract contains these stipulations:

"In consideration of the supplying of said water, said owner hereby agrees to pay for the same in accordance with such rates as are from time to time established, and this agreement to pay shall remain in force and be binding upon him so long as the city of Lynn shall continue to supply water to the said premises, unless he shall have notified the said City in writing that he no longer desires the water service and shall have stated in said notice the name of the new consumer. He agrees to be bound by the rules and regulations of the Water Department and all subsequent changes therein, and to pay all charges for excess piping or special construction as prescribed in those rules and regulations. It is understood and agreed that the City of Lynn does not guarantee to furnish constant pressure nor uninterrupted service."

If a new owner of property fails to make application for water, he receives in due course of time a notice of the following tenure:

"It has been reported to this department that you are the owner of the property at blank street. If such is the case, this is to notify you

* Commissioner of Water Supply, Lynn, Mass.

that under the regulations of this department, you, as the new owner of this property, have no right to the use of water service unless you have made a written application for water on the prescribed form in this office. You are requested to call at the water office, City Hall, within one week and make such application."

Failure to comply with this request is followed up promptly by shutting off the water.

It is necessary to have a contract with the current owner of all property, and to prevent the use of an excessive number of contract cards, each one is provided on the back with space for six transfers of property, the new owner signing this statement:

"In consideration of the continuation of service, I hereby agree to be bound by the provisions of the contract on the reverse side of this card, from blank date, as though I were, in fact, the original applicant."

All applicants for water do not submit just the simple request for a single service, but occasionally an unusual and out-of-the-ordinary use for water is contemplated, or a building is so long that the consumer desires the City to go to the expense of putting in two services instead of his putting long feeder lines in the basement. Such conditions are covered in the regulations by the following:

"Owners of property desiring any unusual construction, alterations or attachments connected with the water supply must submit plans and specifications for the same to the commissioner for his inspection and approval or disapproval, and his determination as to whether the same are permissible, and the terms and conditions under which their use will be allowed."

"Any consumer requiring, because of special conditions in connection with his use of water, a service pipe between the main and the street line which is larger than one ordinarily needed to furnish the total amount of water which he uses, shall be charged the cost in excess of such a service pipe as is ordinarily furnished, both upon the original installation or a replacement thereof."

"Except by special consent of the commissioner, but one service connection will be made for the same premises, and where standby or emergency services are installed the same shall be metered and the entire expense of installation and maintenance of both service pipe and meter shall be at the expense of the consumer."

The consumer who owns a camp to be occupied only a part of the year, or the lunch-cart owner who wants a well-paved street torn up to give him water, and who may be out of business in six months, are cared for by this regulation:

"Services for other than permanent structures, or which are used only a part of the year, will be put in at the expense of the consumer, the cost to be refunded if the service remains in continuous use for five years."

Two other types of consumers, the one who wants a service in a hurry, irrespective of physical conditions, and the other who wants something other than the standard service in order to get out of it cheaply, are met by these regulations:

"When permission to open a permanently paved street is refused by the Commission on Ways and Drainage, or for any physical reason it is impossible to open a street and the applicant requests that water be furnished temporarily from an adjacent service, the same may be done if considered practicable by the Commissioner of Water Supply, but entirely at the expense of the consumer."

"No new service or main extensions will be granted during December, January, and February, except in such cases as the Commissioner of Water Supply shall deem emergencies."

"Service pipes shall not be placed in the same trench with sewer, gas or electric connections except under special conditions and with the approval of the Commissioner of Water Supply."

Many people apply for water when they are beyond the end of the main or are on a new street. Two methods are provided for such cases, one for the consumer who wants real service, and the other for the one who wants to get off easily:

"Extension of mains (except as hereinafter noted) shall only be made after petition by the real estate owners or their authorized agents, along the line proposed, and upon their entering into an agreement, which shall assure an annual revenue to the Department equal to 10 per cent. of the cost of laying not exceeding a 6-in. pipe, dating from the time the water is turned into the same for public use."

"When no main pipe is opposite the applicant's premises, the Department will lay at its expense, twenty-five feet (25) of service pipe from the nearest main, but not beyond the street line at the front of the premises. The remainder, if any, must be laid at the applicant's expense."

The contract which the consumer executes covers not only the supplying of water, but a service pipe and a meter installation. The charge for a service pipe is in accordance with the following:

"All service pipes and street boxes will be supplied and put in by the Water Department and will be laid from the street main through the cellar wall or front of building. Service pipes will be laid to the street line without charge, except where ledge work or blasting work, or digging frozen ground is necessary, in which cases the applicant must prepare the trench to the ordinary depth required to insure protection against freezing, or if equipment and labor are available such work may, at the discretion of the Commissioner of Water Supply, be done by the Water Department at the expense of the consumer."

"All pipes laid beyond the street line shall be charged to the consumer whether on a new installation or a replacement, and water will be shut off for non-payment of pipe bills under the same procedure as for non-payment of water bills."

The consumer who may have two or more houses on a service or sprinklers on his lawn, and who would prefer to save the difference between the cost of work done by the City and by plumbers, is taken care of by this provision:

"The Department shall furnish no material for use on private premises, nor do any work thereon, except underground work directly connected with its main pipe system, and then only at the expense of the consumer."

The man who feels that he is better able to judge whether a service pipe should be repaired or renewed than the Water Department is confronted with the following:

"All service pipes between the street line and the cellar wall may be repaired or relayed by the Department when it deems it necessary for the protection of the supply or the giving of satisfactory water service and the cost of the same charged to the consumer."

It was recognized by the writer that it is very essential for the department to have complete control of the meters, but with 5 500 services unmetered, and the hope that they will be metered in the near future, it was desirable to contrive some means of keeping this control without having to furnish the capital for the installation of so many meters. The following paragraphs from the regulations show how the proposition is handled:

"All users of water through metered services shall pay the cost of a proper-sized meter installation, and thereafter the maintenance of the same shall be by the Water Department, which shall include all ordinary repairs and replacements. All repairs of injuries to meters from freezing, hot water, or external causes shall be charged to the consumer. Charges for a new meter installation will, at the discretion of the Commissioner of Water Supply, if requested by the consumer, be levied in equal parts, due and payable with each of the first four quarterly water bills, and all such charges when paid shall be retained by the Water Department and credited to such meter installation and, in the event of failure to make payment of such charges when due, the Water Department shall have the right to shut off the water under the same procedure as for other Water Department charges."

"The proper size of meter required for any given service shall be determined by the Water Department, which shall in all cases furnish the meter to be used, the same to be such type and make as said Water Department shall deem proper."

"All meters shall be set by an employee of the Water Department, and shall not be moved or disturbed except by the same."

"The department shall have the right to remove, repair, or replace any meter at any time it sees fit. All meter installations on services which cannot be shut off for meter repairs shall be equipped with a by-pass at the expense of the consumer."

"If, in the opinion of the commissioner, a meter does not fit the conditions of the service installation, the Department shall have the right to change such meter and charge or refund the difference in value of the meters exchanged."

Under this method of maintenance of meters by the City, we meet with consumers who, due to the rate at which they use water, desire a very large meter, and others who have stumbled on to the brilliant idea of charging their tenants directly for water. We are prepared for them with the following:

" Any consumer requiring, because of special conditions in connection with his use of water, a meter which is larger than one ordinarily needed to register the total amount of water which he uses, or which is of special material or type of construction, shall be charged the cost of the same, and the upkeep of such meter shall be at his expense."

" Where the supply of water through a service is covered by a single meter, the Department will read and maintain but this one meter. If additional or auxiliary meters are wanted for showing subdivisions of such supply, they may be furnished and installed by the Department, at the expense of the consumer, who must assume all responsibility of reading and maintaining the same."

After the consumer has had explained to him the particular regulations which fit his individual case and has signed the contract form, the usual orders are sent from the office for the service pipe and meter installations, and an account is opened on a card form which is filed alphabetically in the proper district.

No new accounts are opened except for metered water. The fifty-five hundred fixture accounts are hold-overs, and are gradually being done away with. The houses on fixture rates are inspected and billed twice yearly. The metered consumers receive bills quarterly, but as a matter of service all meters are read monthly, and any excessive flow of water is called to the consumer's attention, that he may put a stop to it at the end of the first month. It is illustrative of the peculiar quirks of human nature, that sometimes consumers ask for a reduction on a water bill because we failed, on our monthly round of readings, to get into their locked-up premises and the leak went on for two or three months. Such people are taken care of by this paragraph:

" The Department will endeavor to notify consumers of excessive use of water by the monthly reading of meters, but failure to send such notification or inability to read the meter from any cause shall form no basis for allowance on a large quarterly water bill."

It is interesting to note that it costs as much in a year to make eleven thousand inspections in houses on fixture rates as it does to make ninety thousand meter readings.

One meter bill and one fixture bill only is presented to a consumer owning several pieces of property in one district, the detail being shown on the back of the water bill. All bills are made up in the water office and are sent, together with the commitment sheets, to the collector, from whose office they are mailed to the consumers. At the end of fifteen days, 5 per cent. is added to all unpaid bills, and at the expiration of thirty days

the water is shut off. Forty-eight hours prior to the shutting off, a notice is mailed from the collector's office as a final warning.

That most troublesome class of consumers, those who are always looking for a chance to collect something from the City, are pretty well fortified against in the regulations by paragraphs which set forth that the City does not guarantee constant pressure or uninterrupted service, and that it will not be responsible for any damages resulting from interruption of service, collapsing of hot-water tanks, shutting off without notice, dirty water, nor for conditions in consumers' pipes which cause trouble coincident with or following work done by the City on its pipes.

Were the public educated to understand that their water-works system is an institution which strives to give as much service as possible for the money which the public expends, there would be less and less need for rules and regulations, and it is to that end that we must all work. It is a hard proposition, however, especially in communities made up, as Lynn is, of a large proportion of foreign-born people. A great many of these people seem very apt in learning how to beat the Water Department out of money, but very slow in getting a viewpoint which will cause them not to want to do such a thing, to realize that it is their own business that they are trying to cheat.

Our great weakness in dealing with the troublesome ones comes from the fact that in Massachusetts water bills are not liens on property, and there has sprung up in Lynn a clique of operators who, by rapid transfers of property among several of the gang, leave us up in the air in regard to shutting off water to collect the unpaid bill, as of course the new owner cannot be held for water that the former one used. We have a provision which allows us to require a deposit in advance when we deem it necessary, but it is hard to give a reason why this should be applied until we have a record of an individual having at least one unpaid bill against him, so we are continually losing money in spite of such a provision. Many such people have no visible assets, and in nearly all cases the individual bills are too small to justify a suit. It certainly is a condition which there should be laws to remedy.

Much has been said about education of the public, and no one is a stronger believer in that than the writer, but certainly up to date, as a substitute for penalties and charges, it fails in a city like Lynn. Before using a 5 per cent. penalty on unpaid bills, there existed a chronic group of delinquents to whom the 20c. summons was a joke, and offers to test meters free to show our faith in their accuracy was met by a deluge of requests from consumers who in some cases had received bills less than a dollar above the average.

While many of the methods described above are stringent, it must not be forgotten that to the good fortune of water-works officials the vast majority of water consumers scarcely need to know that there is such a thing as rules and regulations.

Discussion.

Mr. Charles W. Sherman.* The whole backbone of the operation of a water-works system is in its rules and regulations, especially in so far as its relations with consumers are concerned. Mr. Newsom has done a real service to water-works men in putting on record some of the most important provisions which he has framed for use in Lynn, and which I am sure will be of great assistance to many of us in making the revisions that periodically become necessary in meeting conditions that our old rules and regulations do not cover.

President Macksey. In relation to trying to hold a man who passes title to property without paying his water bill, in Woburn we changed our contract so as to read that the party who made this contract agreed that we might, in the event of his non-payment, shut off the water not only on that property but on any other property which he might own in the city, which gave us a chance to collect some bills from real-estate owners who were holding to sell.

Mr. Henry A. Symonds.† What are the rights which a water department or company has, to shut off water for non-payment of water rates? That point was passed upon a few years ago by the Supreme Court in a case where the owner of the property had failed to pay the water bills. The owner claimed that the water was shut off illegally when done for the purpose of collecting the tax. He brought suit and, it was reported, recovered damages. At any rate, the decision of the Supreme Court was in his favor. I have been wondering whether we have been acting illegally in many cases in this matter, and under just what conditions we could shut off water and when not. I submitted that question to our counsel a short time ago, who made a somewhat careful study of it. His opinion was that we had a perfect right to shut off the water; that is, to discontinue furnishing water in the future, on the ground that a party was proving a bad customer, unless he had made the proper payments, but he was of the opinion that we did not have a legal right to shut off water for failure to pay for service which had been rendered in the past as a means of collecting; that our remedy was to bring suit.

Mr. Newsom. We have never, to my knowledge, experienced any particular difficulty in shutting off water. I, too, have talked the matter over with the city solicitor in connection with other regulations, — other things that we sometimes wished to do in order to make consumers act properly, — and he seemed to think that if the regulations are carefully enough drawn and are specific enough, and if in the contract which the consumer signs he agrees to be bound by those regulations, we should probably have no difficulty in carrying them out. That applies to most of them, I should say; but until such time as they are tested they accomplish

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a great deal of good, and you have sometimes to depend on the fact that the public will do almost anything at all reasonable rather than go to court; and as long as you keep your regulations within the bounds of reason I think you have a chance to get them by most of the time. As far as shutting off water goes, however, we have never had any difficulty in that line that I know of.

A PRACTICAL TALK ON SOME WATER-WORKS MATTERS.

GEORGE H. FINNERAN.*

[*September 10, 1920.*]

It is interesting to consider the changes which have occurred during the present generation in the methods and means of doing the work of a water-distribution system.

The automobile has replaced the horse, and while it has speeded matters it has brought its own troubles. The tapping machine, with its special sleeves and valves, and the valve inserting machine, have replaced the old method of shutting down, cutting out with hammer and chisel, and pumping.

Electrical thawing has replaced the slower and more tedious method of injecting hot water into the pipes. The automobile attachment for closing and opening large gates has made their operation easy and quick, — a big factor in general maintenance and in main-pipe breaks of serious consequence.

Electrically driven pumping units, largely of the centrifugal type, mechanical stokers, and mechanically operated valves have made pumping stations more efficient.

The various jointing compounds have to a considerable extent superseded lead, thereby saving bell holes, calking, and cost of material. In some parts of the country cement is now being used as a jointing material. Cast-iron water pipes are being manufactured and sold with lead joints in the bells, ready for calking.

The trenching machine under certain conditions is displacing the pick and shovel. Gasoline and electric power-driven pumps are employed where hand-worked diaphragm pumps formerly were used. The air compressor combined with pneumatic tools has replaced hand rock drilling and hand calking. The differential hoist with its duplex and triplex blocks is used to advantage in laying main pipe, displacing the rope tackle and the cumbersome winch.

The leak finder, pipe locator, gate finder, aquaphone, detectaphone, transmit-o-phone, geophone, sonoscope, sonograph, sounding rod, pitometer, manograph, and Venturi meter, all tend to facilitate the work of stopping leaks, minimizing waste, increasing revenue, etc.

Plunger piston meters have given way to the rotary and oscillating disk types, with more accuracy especially in small flows. The compound meter with its wide range of service has made it practicable to meter pipes with considerable variation in the rate of flow. Meter testing has been much facilitated by improved apparatus.

* Superintendent, Boston Water Works.

The patented flanged couplings or dry couplings, as they are sometimes called, have to a large extent displaced the plumber and his solder joint.

Electric and acetylene lights have made night work practical. The hand flashlight has replaced the antiquated and dangerous candle and the smoky and smelling lantern. The oxyacetylene torch is every day proving itself to be a money saver by its ability to repair broken castings and metal parts that formerly were considered as beyond repair. The plumbers' torch has replaced the old charcoal furnace with its soldering iron. Gasoline and kerosene lead-melting furnaces are used where formerly wood and coke supplied the heat. The large blow-torch melts out the lead joint where in the old days a fire of wood or charcoal was built under the pipe.

Steam, slacked lime, charcoal, and the blow-torch are now used to remove frost from the ground. Calcium chloride, denatured alcohol, glycerine, and kerosene are applied to hydrants as anti-freezing materials. The natural heat of the ground is intelligently utilized to prevent freezing of meters and hydrants.

An improved type of force pump combined with up-to-date methods has made the clearing of stoppages easier and more successful.

The development of the telephone system has facilitated the direction of outside men through means of frequent communication between headquarters and near and distant points.

The development of the emergency gang has resulted in quick service to the public and the control of leaks and breaks with a minimum amount of damage.

The development of water-works associations, with their meetings and journals, interchange of opinions, recital of experiences, collection of data, the work of committees in standardizing specifications, the influence of the organizations in promoting beneficial and desirable legislation, etc., have tended in a very great degree to advance the ways and means of operating a water-works system.

The changes indicated in the foregoing have in almost every case proved to be an improvement and a step forward along the line of efficiency. They are, however, chiefly mechanical. In the labor end of the work, I regret to say there has been no great improvement either in quality or quantity. If it were not for the compensating effect of the many mechanical devices introduced into the work, and increased earnestness and energy on the part of the directing forces, I fear we should not have much to report under the head of results.

Especially during the last few years, labor as a whole has declined in zeal. It appears to have lost interest in the work. We do not see it displaying the initiative and the sense of duty that was usual in the old days. The newcomers do not have the manner of one intending to stay, to acquire experience and skill as a water-works man, and become part and parcel of

the system. Rather do they impress one with the idea that their service is to be temporary, a mere filling in while they are getting an easier and higher-class job. Possibly this may not be the case in private water companies where the management has a wider scope of selection and full powers to hire and discharge, but in municipal systems I think it will be found so.

There are of course good working men in every water-works system. They are usually of the old stock, and have been in the employ of the cities and towns for some time. They are the stand-bys, the real props, and without them matters would be well-nigh hopeless. They are fast dropping out through infirmity or death, and their replacement is a serious problem.

Contract work can be used to advantage in extending and relaying mains and other new work, but in general maintenance the work is of such a miscellaneous and complex character, and governed by conditions which cannot be foreseen, that men with special qualifications acquired by experience are necessary. Moreover, these men must be on hand at all times and under full control of the management of the plant. To fulfill these specifications a regular force of day workers is necessary, — men who have become attached to the plant with the intention of permanency. It must be practically their life work.

In a certain sense this is asking a sacrifice on the part of some men who might meet with opportunities in other lines.

Realizing this and understanding that the value of a man, with certain exceptions and limitations, increases with the length of time devoted to the service of the department, the management should treat their worthy men appreciatively, and generously recognize the value of their work.

In some cities and towns this is being done to a certain extent by pensioning the laborers and mechanics, but with my limited knowledge on this subject I am not aware of any provision being made to pension foremen or superintendents. This, to my mind, is not exactly fair. The average general foreman or superintendent in a municipal water works devotes his period of productiveness and maximum energy to the public service. After passing that period he is unfit to start in any new line of business and successfully compete with younger men. The very nature of his work is such that he does not meet with opportunities for advancement. He is confined to a certain routine and limited to a certain area of action. He cannot go far afield. He must hold himself in readiness to answer the call. It may come when he is in one end of the district or the other, when he is awake or asleep, when he is at home or in church, or possibly in the theater if he allows himself such a respite from his labors. For my own part, I have acquired the habit of calling up headquarters on the 'phone, whenever I am away from the office or home for any length of time, to learn what has occurred in the meantime. I recall one such occasion previously to entering the theater, when I was informed of a serious break in a 36-in. main in the downtown section. Had I omitted to make

this inquiry I should have sat through a performance for almost three hours blissfully ignorant of that which to a water-works man is a tremendously important event, namely, a bad break, in a large main, in a congested section.

This concentration of the mind on water works has a tendency to subordinate all other matters, and restricts our field of action to a limited extent. The consequence is that we do not get into the main currents of life, making contacts at various points with diverse interests, as do some men in other lines of work. Hence opportunities which usually come from such contacts are denied us, and those who are not well fitted for the work we are engaged in are unable to find our right places in the world. We continue as mere water-works men, doing the day's work with no expectation of recognition or reward, and only the satisfaction which comes from a faithful performance of one's duty.

However, to revert to the subject of a proper recognition of the value of the men's work, I must say that workmen have not fared so well in the water-works line as they have in others: I am speaking now for Boston. Ordinary unskilled labor in many cases that I know of has been paid a higher rate of wages on the outside than some of our own skilled men, and as for calkers I know of several places where contractors have paid them one dollar an hour. This has a very disquieting effect on our men, and unquestionably has diverted their interest from the work. So far as the remuneration of superintendents goes in these days of high wages and high cost of living, I feel safe in saying that it has not advanced proportionately with that paid to men holding positions of equal responsibility in other lines.

Before leaving this subject of labor I should like to call your attention to the self-assertion of men in recent years as compared with their docility in previous times. While I daresay it is not peculiar to those employed in water works, yet I cannot help observing it because it is so comparatively pronounced. Upon the slightest pretext a protest is made to this condition or that grievance. Extra attention is paid to the classification of the work. Men are inclined to specialize more than ever. One has to be careful in asking a handy man to lay a few bricks or cut some stone, or repair artificial stone sidewalks; or in asking a carpenter to tack some sheet iron instead of a board to a wall, and so on. You probably will be told by the man that he is not a bricklayer, or a stone-cutter, or a mason, or a sheet metal worker. You may also be told, "I don't get the money," or "I don't care to scab."

All this is part of the doctrine of unionism, and from certain standpoints is perfectly proper, but it does sometimes slow up the work, especially when one is particularly anxious to do a quick job.

Great care and attention is now necessary to keep the men working harmoniously and coöperatively. Temperament is ever present. A superintendent has to be a near-psychologist, to diagnose the mental oddities

found among the men. There are some men who work better alone than with others. There are some men who expect to be told what to do, step by step. Others resent such interference. There are individual preferences about working together, some likes and intense dislikes. There are suspicious men and notional men. There are tricky and sneaky men, and there are downright dishonest men. There are stupid men and slow men and lazy men. There are destructive men and dangerous men. There are chronic whiners and men unable to stick for any length of time to any particular kind of work. There used to be drunken men, but I am glad to say that since prohibition we have very few with that failing. When the bootleggers are exterminated we shall not have even that few.

Happily, there are many men who are normal and well-balanced, but it requires much ingenious effort to combine the numerous diverse dispositions into a well-working machine.

As for politics, those of us who are in municipally-owned systems know that it is an ever-present factor operating usually to the detriment of the service. It is so common that we have almost accepted it as a necessary evil. Just so long as the individual is willing to advance his own selfish interests, at the expense of the community, will municipal work suffer a handicap and fall short of real business efficiency. In Boston, I am glad to say, matters have improved within the last few years, and the situation in this respect is quite hopeful.

There is another disadvantage which the work of a water-distribution system endures, and that is its hidden nature. We are underground workers. Immediately upon completion of our work we cover it with five or six feet of earth. We cannot display our wares. I have often seen a very fine example of pipe work where the pipe layer was so proud of it that he delayed filling in until somebody in authority could view it. It seems too bad that the public does not see more of our work. It is our lot, however, that we are seldom thought of except upon rare occasions when the faucet is open and the usually never-failing gush, of one of the most important substances in the world, is missing. The work of the paving, street cleaning, and sanitary branches of the public service is continually before the eye. The public is in contact with it through some of the senses, and consequently it is catered to. It is like the handsome daughter of a family, dressed up, kept in the foreground where all may behold her charms, while her plainer and more utilitarian sisters, water and sewerage, are kept in the background, very often furnishing the wherewithal for the embellishment of their fairer sister.

I realize that my remarks have a pessimistic tone, but we all know there is a bright side to the picture; that in water works, as in all other work, there is joy in the accomplishment. We are conscious of rendering the public a great and necessary service. We are constantly meeting with problems and obstacles, but upon applying ourselves to them they flatten out and disappear, and in direct proportion to the greatness of the difficulty

is the glory and satisfaction of achievement. This swimming against the current and sailing against the wind is the best means of developing our character and capabilities, and we should be thankful for the opportunities of this sort which our line of work presents.

In connection with the question of compensation, I thought it would be of interest to others to know what we are paying our workers in Boston. We receive frequent inquiries on this subject.

Laborers receive $4.00 a day of eight hours' duration; calkers and repairers, $4.25 to $4.50; pipe layers, $5.00; plumbers, $4.50; chauffeurs, $4.50; machinists, carpenters, blacksmiths, $5.00; pavers, $5.00; meter repairers, $4.50; drillers and assistant machinists, $4.00 to $4.50; and a variety of rates for bricklayers, stone cutters, electricians, storekeepers, yardmen, etc., ranging from $4.00 to $6.60 a day. Foremen, inspectors, and clerks are paid salaries ranging from $4.50 a day to $2 300 per year. Meter readers are paid $1 400 to $1 500 per year, and engineers and superintendents $1 100 to $5 000.

All overtime — that is, all time in excess of eight hours — is paid for at the rate of time and one-half except on legal holidays, when the men who work and who receive day wages are paid double time. Salaried men who work on holidays are allowed time off. All men who work Saturday afternoons are allowed time off and are not paid extra. If a man should work Sunday on a charged job he is paid double time. The emergency men work seven days a week and receive only straight time except for holidays, when they receive double time. All men receive two weeks' vacation without loss of pay. Also, in the event of the death of a father, mother, brother, sister, son or daughter, they are allowed three days without loss of pay to attend to funeral matters. All laborers and mechanics receive a pension of $360 per annum after working twenty-five years for the city and having reached the age of sixty, and having been pronounced by an examining physician to be unfit for work.

There is another provision which authorizes the City Council to retire a laborer or a mechanic upon a pension of $360 per annum after fifteen consecutive years of service, with no age qualification, but with the requirement of a certificate of disability from an examining physician. Before becoming operative the approval of the mayor has to be secured.

Veterans of the Civil War are retired at any age upon half the pay they are receiving at the time of retirement. Disability is necessary in this class as in others.

A retiring board consisting of the city auditor, city treasurer, and the mayor, decides finally on all retirements and they become operative only after said board gives its approval.

Automobiles.

There is no question but what the automobile is a permanent institution in all water-distribution systems. It has "speeded up" the work

and increased the capacity to serve. Its advantages are so obvious that it is superfluous to state them. It is a machine, however, and notwithstanding the efforts of the manufacturers to simplify its construction and make it foolproof, it is complex and contains many parts which get out of repair and cause delay and interruption to the work, usually at the most inopportune time. This breaking down is so certain that it is necessary in order to maintain uninterrupted service to have a reserve equipment. Just how much this reserve should be is a question depending on local conditions. I have heard it placed as high as 20 per cent. In other words, one fifth of the total number of vehicles should be kept in reserve to replace any of the remaining four fifths which might break down. In my opinion, this is placing the reserve figure rather high. In Boston we have been able to keep the equipment going with slightly less than one half of that. I must admit, however, that during short periods of stress we could have used a few more autos. Accidents, like other happenings in the world, appear to be more or less epidemic.

We have in the Boston department about 35 autos, mostly Ford runabouts for passenger transportation and Ford one-ton trucks for materials. We are not entirely motorized, as there remains provisions to be made for heavy hauling, — three to five tons, now cared for by horses, and there are kinds of work, like patch paving for instance, where a horse and wagon is more economical. In such work a horse and wagon carrying tools and materials stands around waiting on the men. I find that where there is much waiting an automobile is not economical. You get the best results by keeping it moving as much as possible with a minimum amount of time spent in stop-overs. To properly do this it is necessary to prepare its work ahead of time; or, if that is not possible, have it call up headquarters upon the completion of each job and receive directions for its next move, which very often may be conveniently near the location of the auto and thus save doubling back to the spot after arriving at headquarters.

In our "off-and-on" work, which consists largely of shutting off services to permit private plumbers to make repairs, and afterward turning on, this method of telephoning to headquarters is almost indispensable. It is a requirement in our emergency service and is found of much advantage otherwise.

The trouble with automobiles, as with other branches of the work, is the personal factor. If we could get men who had a mechanical conception of the automobile combined with a careful and considerate make-up, the cars would give much service with a small amount of trouble. We find, however, that many men who drive cars do not understand the principle of the gasoline engine. They do not know the "why" of this or that part. They are not sensitive to the little warnings which the machine gives out preceding its eventual breakdown. They are not sympathetic towards its eccentricities. They simply start the car, steer

clear of obstacles, go as fast as they can, and stop in as short a length as possible. Thus will they continue until something occurs to prevent the car from working properly and then there is a job for the repairers. They take the car given them in place of the disabled one, and repeat the operation. We try, of course, to show them the trouble and explain the cause, but somehow history repeats itself.

We find it necessary to pay strict attention to the oiling and proper inflation of the tires. Partial deflation of tires shortens their life considerably. We have a night man whose duty it is to inspect each car in the garage. If he finds any serious trouble or defect he places a tag on the car forbidding its use the next day, and reports the trouble in the morning to the auto repairers. He puts oil into the crank case, attends to any flat or partially flat tires, fills the gasoline tank, turns down the grease cups, cleans and polishes some of the cars, puts water in the radiators, etc. In the morning one of the repairers arrives before eight o'clock and starts up some of the obstinate cars, of which there are always a few, especially among the Fords and during cold weather. The idea is to have the car ready for immediate use when the day's work begins.

Many of our cars are driven by the men who use them; for instance, the district foremen drive themselves, the plumbers and meter repairers likewise; so also the "off-and-on" men, the engineers, myself, and even the division engineer, the head of the department. We try as far as possible to eliminate dead weight on the cars in the form of chauffeurs who only drive.

We keep the usual records of oil, gasoline, tires, upkeep, etc., but I find that while such records are valuable and necessary, yet they do not tell the whole story when used for comparison with the mile as a unit. There are miles and there are miles. Some of our cars are used exclusively in the congested parts of the city; some in the suburbs. A mile in one section means much more than a mile in the other. Stopping and starting necessary in the downtown streets, the bad pavements in some sections, the hills in other sections, all tend to influence differently the wear and tear on the tires and machinery and the consumption of gasoline and oil. There are such things as hard miles and easy miles. If you will notice, the tire manufacturers are not adjusting on the basis of numerical miles. They wish to know if the tire was on the rear or the front wheel, and they inspect it closely to observe whether or not the reported mileage was of the hard, backbreaking, abusive kind, or of the smooth, velvety, park-road brand. It makes a difference.

One thing is a certainty, in connection with the upkeep of autos, and that is, it pays to buy the best tires, the best lubricating oil, and the best quality of gasoline. It pays to watch the cars closely and continually, repair them at once if there is indication of defect, — do not delay. Watch the tires for under-inflation. Compare the records of the different cars, making allowances for the various conditions under which they are used,

and watch the man who drives the car and discover if possible his weaknesses and mistakes and correct them in the proper manner. Automobiles cost a lot of money to keep in service, and they should be worked to the maximum.

Blow-Offs.

To use the expression of our workmen, the blow-off is a great thing.

It consists of a three-way branch or tee inserted in the main line, the branch lead being 4, 6, 8, 10, or 12 in. in diameter, according to the size of the main of which it is a part. The branch lead is usually off the bottom of the branch so as to drain the pipe completely, and is controlled by a valve. It is connected with a sewer or waterway of some kind.

Originally the blow-off was intended as a cleansing agent through which bad water might be blown into the sewer. The velocity of the flow was supposed to detach the accumulations of the interior surface of the pipe and carry them into the sewer. We find, however, that it is difficult to confine the "riling up" effect of the fast flow to any local section, and instead of improving conditions we sometimes make matters worse, especially when we are thoughtless enough to "blow off" on a washing day or in the vicinity of some large laundry or dyehouse.

Another use planned for these fixtures was to drain the contents of the pipe into a sewer or other channel, and thus make the work of repairs or replacement, or the plugging of an abandoned service connection, easier by getting rid of the water without pumping.

In a system as old as that of Boston, with a surface water supply that easily makes rust, the interior of the pipes is more or less filled with corrosion and other growth. The seats of the valves are soon filled with the same material, and regardless of whether they are run up and down periodically it is a difficult matter in many cases to close them tightly. In such cases the blow-off is of much help, by draining off the leakage and keeping it away from the point of work where it would of course interfere with the making of the joints. That is why our men call it "great" and demand more of them.

In parts of our high-service system where it supplies only sprinkler pipes and a few service connections to extra high buildings, we have been put to much trouble recently because of the absence of blow-offs. They were not installed in such lines, and now when occasionally it becomes necessary to repair a gate, plug an abandoned service connection, or drill a new connection dry, — that is, where we are unable because of insufficient space to use a regular drilling machine and we shut down the main and drill into it with a simple brace and bit, — we find difficulty in getting rid of the locked-in pressure. It requires some time for this pressure in a long section of main to spend itself through a $\frac{5}{8}$-in. hole or even a smaller hole, as in the case of the dry drill. It becomes necessary in such cases to let it flow out and use the pump, or if we can find some fairly good-sized con-

nection leading off the main into some building we open it and draw off the excess water.

In the case of leaky gates, however, there is nothing that can be done except to shut back of the bad gates or "fight" the water — as our men express it — with pump, and quick work in making the joint helped out by a clay dam.

There are other things, however, to be considered in connection with a blow-off. It is a potential danger of waste and low pressure. Unless great care is exercised a blow-off is sometimes opened by mistake, or left open, or only partially closed. It continues in this condition until discovered. In the meantime much waste has occurred and increased pumping necessitated to maintain the pressure.

The very nature of the blow-off requires it to be placed at a low point in the line of pipe. Where sewers are not available it is customary to set the outlet in waterways, dikes, culverts, and even in the harbor wall. Care must be taken in such cases that the blow-off be kept closed when the tide is high or when the water level is up to the grade of the blow-off. It is an easy way to get infected water into the main. It is of course possible to flush the main, but the danger lies in overlooking the occurrence.

Where they enter sewers and sewer manholes care should likewise be taken to guard against the possibility of the sewer filling and backing up because of stoppage or a heavy storm. One cannot be too careful on this point. Check valves may be used as a protection but they cannot be depended upon absolutely in such an important matter. Personal attention of the most careful kind is the only preventive.

Filling a Main Line.

To the average workman, filling the main line is a very commonplace affair, but to the competent and painstaking man it is a very important matter and requires time measured by the diameter and length of the main. The important thing is to get rid of all the air. In ordinary distribution mains to which hydrants are connected, this is not a hard matter, as by opening one or more hydrants the main pipe is vented and the air allowed to escape as the water displaces it. In large transmission mains, air valves placed at high points in the grade line are the only means of letting out the air. There should always be at least one air valve of at least 2 in. in diameter in each section between gates and located at the highest point of the pipe line. If the grade line of the pipe is undulating, a valve should be placed on every summit. If gates are located at high points it is well to have an air valve close to the gate on each side.

A man should be stationed at each valve in the section to be filled, with wrench or key to control the valve when the air is expelled and the water comes. Not every man is suitable for this job. The roar of the air escaping from a large main has a bad effect on a nervous man, and he is

inclined to shut the valve before all the air is out. As the filling of the pipe nears completion the air and water rush out alternately, caused by the breaking down of air pockets and the surging of the water in the pipe. If the manhole in which the valve is housed should become filled with water, these rushes of air and water are apt to cause violent splashes and consequent wetting of the man with the wrench. A timid man may desert his post or allow the wrench to become displaced on the air valve, and it is a hard matter sometimes to replace the wrench on account of the agitated state of the water in the box or manhole and its increasing pressure. An experienced man can usually tell when the air is all expelled. The discharge becomes more uniform and the water loses its white, foamy appearance.

If there are small by-passes around the large gates the filling of the pipe should be done through one of them, choosing the low end of the section. If there are no by-passes there is usually at least one connection of smaller diameter than that of the main to be filled. Fill through that. If there are no by-passes or connections, open one of the large gates a very little and admit the water very slowly from the lower end of the section if possible. It is usually a hard matter to open a large gate with the pressure on one side only. Care should be taken to avoid breaking the gear or the screw.

I have observed the filling of a section of large main through a 12-in. connection on the high end of the section. The only air valve was located on that end also. The inrushing water flowing down grade through the empty pipe caused the outside air to be drawn in through the open air-valve, thereby reversing the natural order of things. When the pipe began to fill, the water within started to surge violently, and there were periods when the air was sucked in from the outside, followed by periods when the air and water mixed was driven out with great force. This continued for some time, and it is a question whether or not the air was completely forced out. Probably when the gates were raised it worked its way through the system, gradually finding its way out through taps in buildings.

It is right here that the danger lies. If the air is not completely driven out of the pipe it will find its way out somehow, and it is often the case that it works its way out through the top of a joint or through the stuffing-box of a gate valve. This means, in the case of the joint, a weakening of the same; and a leak starts then and there. It is not an unusual thing that when a large line is shut down and emptied or partially emptied to make repairs, not long after it is turned on a leak is reported in the street over the line. This happens notwithstanding our efforts to have the line properly filled, showing how difficult it is to rid the pipe line of all the air. Joints are often blown out by air.

We see the effect of air on the dial of the pressure gage, which shows violent oscillations of the pressure indicator. The collapse of air pockets

in the pipe sometimes produces powerful concussions which have a bad effect on the pipe line and cause a movement in the same at some weak point.

It is therefore of great importance that the utmost care be exercised in filling pipes. Do it slowly. If possible, let it dribble in. The trouble is usually caused by impatient men who will not wait for the line to fill slowly.

In this rather rambling talk, on a few disconnected matters that we meet with in the day's work, I realize that I may not have added much to the general fund of information, but I feel that I have at least implanted a few thoughts in your minds which may result beneficially, one way or another.

Discussion.

W. C. Hawley.* I think that Mr. Finneran has covered the ground very completely. In our pipe system we occasionally find a gate valve which cannot be closed because of the accumulation of sand, etc., in the bottom of the valve, which prevents the gates from seating. By closing and opening the valve several times, sometimes as many as a dozen or fifteen times, we are generally able to blow the foreign matter out and close the valve tight. Our instructions to the men, in such cases, are to close the valve until it stops, but not to attempt to force it home. By repeated opening and closing we can gain a fraction of a turn each time, and soon the gate can be closed. We do not, of course, open the valves wide each time, but just enough to raise the gates from the sand, etc., which has collected in the bottom, so that the current of water passing through will tend to force the sand out of the bottom of the valve.

* Engineer for Pennsylvania Water Company.

INSTRUCTIONS TO EMPLOYEES AT PUMPING STATIONS AND FILTER PLANTS.

DOW R. GWINN.*

[*September 8, 1920.*]

Human nature is very much the same in Indiana and Illinois as it is in New York and Oregon. The tendency is to move along the line of least resistance, — to do things in the easiest way. There are cases where the easiest ways and efficiency are not synonymous terms. In operating water plants the author has tried to find the best way of doing things, and then to adopt them as standard methods, even if they are difficult, and holding to them until better ways have been found. After methods have been adopted it is discouraging to find, later on, that they are not being observed by assistants. On inquiring why certain methods have been discontinued, the usual answer would be, "We don't do it that way any more." And further inquiry would not disclose why or when the method was discontinued. The idea of printing instructions was then tried; it has worked very well. There is an advantage in having a particular time to do certain things such as cleaning the heater, blowing down the boilers, taking indicator cards, making evaporation tests, etc. The instructions are typewritten and are kept in a loose-leaf binder. Changes can be easily made and additional sheets may be readily added. No method is so sacred but that it can be changed by the manager. The employees are encouraged to suggest better methods, and when tried and found to be advantageous they are substituted for old ones. Each employee is supposed to read the instructions once a month; he may select his own time while on duty for the reading. A sheet of properly ruled paper is enclosed in the file, on which are the list of employees, and each employee records the date when he reads the instructions.

The Terre Haute plant takes its supply from the Wabash River, and is a direct pumping plant, there being no standpipe or elevated reservoirs which could be used if pumps were not in operation.

For pumping into the distribution system there is a ten-million vertical triple expansion and a six-million vertical compound; also, smaller pumps. For delivering to the sedimentation basin there is a centrifugal pump operated by a compound high-speed engine connected with a rope drive. Steam is generated in water-tube and fire-tube boilers with hand firing. A vacuum pump for exhausting air from the suctions of the principal pumps is a part of the equipment. There are 22 mechanical pressure filters. There is a sedimentation basin with sufficient capacity for

* President and Manager Water Company, Terre Haute, Ind.

approximately two to five hours subsidence. This is only used when the turbidity exceeds, say, 60 on the Jackson turbidimeter, or about 55 per cent. of the time. The turbidity of the river water ranges from 25 to 3 000. The pumps work against 70 lb. domestic pressure and 125 lb. fire pressure. The available fire pressure at hydrants in business or high hazard district is 100 to 110 lb. While the fire department is equipped with pumpers, they are seldom used, the pressure from the plant being usually sufficient. There are 100 miles of mains, 62 per cent. being 8 in. and larger diameters. There are 1 155 public fire hydrants. There are 8 240 consumers; 97.7 of all service pipes are metered, including private fire lines for automatic sprinklers.

The Terre Haute Water Works Company.

Names.	1920.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.

These instructions are to be read monthly and the date of reading recorded in the proper column.

Suggestions for the improvement of the service are respectfully invited.

No man can know too much about his work.

Please bear in mind that you are guarding the water supply of your home city.

Be faithful in the discharge of your duty.

At the plant a program clock is provided, which summons the attendants every half hour to examine the water; this is just a visual examination of the raw and filtered water, and a record of the appearance of the water is made. This is necessary because of sudden changes in the turbidity of the raw river water.

A record of fire alarms is kept, showing the length of time extra pressure is maintained, increase in pumping rate, time of receiving alarm and strike out; also, hydrants used and condition after fire. Inspectors answer alarms received from high hazard districts during day, and second

THE TERRE HAUTE WATER WORKS CO. Day, *Thursday*. Date, *July 15*, 19*20*.

At signal observe both raw and filtered water, and record appearance of filtered water: O.K. — All right. S. — Slight variation from standard. M. — Medium. B. — Bad.
If any observation is unsatisfactory, DO SOMETHING, AND DO IT QUICKLY. Use No. 5 for immediate results.
Record changes made by numbers as per margin, but only changes made for correction are to be recorded.
If, for any reason, observation cannot be made within five minutes of the time, leave space blank.
Each engineer should compare time of recording clocks with correct time during his watch.

W. E. TAYLOR, Chief Engineer.

METHODS OF CONTROL.

1. Use of Engine No. 5.
2. Turn in basin.
3. More water from basin.
4. More alum in water to filters.
5. More alum in water to basin.
6. Reduce rate of certain filters.
7. Wash small filters
8. Wash large filters.

Time.	Appearance.	Observer.	Cl. Manometer Reading.	Changes Made.	Time.	Appearance.	Observer.	Cl. Manometer Reading.	Changes Made.
A.M.					P.M.				
12.30	*O.K.*	*M.*	*30*		12.30	*O.K.*	*R.*	*32*	
1.00	*O.K.*	*M.*	*28*		1.00	*O.K.*	*R.*	*34*	
1.30	*O.K.*	*M.*	*20*		1.30	*O.K.*	*R.*	*34*	
2.00	*O.K.*	*M.*	*20*		2.00	*O.K.*	*R.*	*34*	
2.30	*O.K.*	*M.*	*20*		2.30	*O.K.*	*R.*	*34*	
3.00	*O.K.*	*M.*	*20*		3.00	*O.K.*	*P.*	*34*	*Charts*
3.30	*O.K.*	*M.*	*20*		3.30	*O.K.*	*P.*	*30*	*O.K.*
4.00	*O.K.*	*M.*	*20*		4.00	*O.K.*	*P.*	*30*	
4.30	*O.K.*	*M.*	*20*		4.30	*O.K.*	*P.*	*30*	
5.00	*O.K.*	*M.*	*20*		5.00	*O.K.*	*P.*	*25*	
5.30	*O.K.*	*M.*	*20*		5.30	*O.K.*	*P.*	*25*	
6.00	*O.K.*	*M.*	*20*		6.00	*O.K.*	*P.*	*25*	
6.30	*O.K.*	*M.*	*20*		6.30	*O.K.*	*P.*	*25*	
7.00	*O.K.*	*B. W.*	*20*	*Charts*	7.00	*O.K.*	*P.*	*25*	
7.30	*O.K.*	*R.*	*20*	*O.K.-*	7.30	*O.K.*	*P.*	*25*	
8.00	*O.K.*	*R.*	*35*	*B. W.*	8.00	*O.K.*	*M.*	*25*	
8.30	*O.K.*	*R.*	*32*		8.30	*O.K.*	*M.*	*25*	
9.00	*O.K.*	*R.*	*32*		9.00	*O.K.*	*M.*	*33*	
9.30	*O.K.*	*R.*	*32*		9.30	*O.K.*	*M.*	*33*	
10.00	*O.K.*	*R.*	*32*		10.00	*O.K.*	*M.*	*33*	
10.30	*O.K.*	*R.*	*32*		10.30	*O.K.*	*M.*	*33*	
11.00	*O.K.*	*R.*	*32*		11.00	*O.K.*	*M.*	*33*	*Charts*
11.30	*O.K.*	*R.*	*32*		11.30	*O.K.*	*M.*	*33*	*O.K.-M.*
NOON.					MID.				
12.00	*O.K.*	*R.*	*32*		12.00	*O.K.*	*M.*	*33*	

GENERAL OPERATING RECORD.

Pounds of coal, *23 190+5%, 1 150=24 340*
Pounds of ashes *2 620*
Percentage of ashes *11.3*
Gallons, high service* *5 605 600*
Gallons, low service* *5 605 600*
Gallons per pound of coal *241*
Turbidity at 7 A.M. *550*
Stage of river *5.6*
Rainfall, inches . . . .
Temperature of water . . . *26° C. = 78° Fah.*
Basin on, hours *24*
Alum, grains per gallon *3.07*
Chlorine, pounds per million *4.6*
Repairs and principal work outside of operation:
Per cent. wash water *6.1*
Alkalinity, parts per million *140*

Total hardness — soap method, g.p.g. *13.5*
Average rate per day per acre *104*

BACTERIOLOGICAL

Raw water per c.c. at 37° C. *3 000*
Filtered water per c.c. at 37° C., *20=99.3%* efficiency
Raw water, B. coli, 1 c.c. sample . . . . . +
Filtered water, B. coli, 1 c.c. sample . . —
Filtered water, B. coli, *5*–10 c.c. samples,
Filtered water, B. coli, No. 10 c.c. samples, positive *0*
Filtered water, B. coli, No. 10 c.c. samples, negative *5*
Filtered water, No. 10 c.c. samples showing gas . . . . 24 hrs., *0* 48 hrs., *0*

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* No allowance for slippage.
NOTE. — In above table, italics indicate actual records.

alarms at night. Engineers and firemen are on duty eight hours; that is, they are off duty sixteen hours per day for six days and the seventh day they are off twenty-four hours. Monday is change day, when each man moves up one watch, the duties during the eight hours being performed by other employees. The changes are made at 7 A.M., 3 P.M., and 11 P.M. Employees are given two weeks' vacation with pay. Baths are provided for the men, also books on engineering and technical publications. The grounds on which the station is located were laid out by a landscape gardener and are very beautiful. A fine tennis court is provided. Long periods of employment are the rule, one engineer having recently completed thirty years of continuous employment. The company arranges and provides for an annual picnic on the station grounds, for employees and their families.

The instructions which follow have been found to be satisfactory for the Terre Haute plant, and while they would not be suitable in every particular to any other water-works plant, they may be suggestive and valuable to other operators.

THE TERRE HAUTE WATER WORKS COMPANY PUMPING AND PURIFICATION DEPARTMENTS.

General Instructions.

These general instructions are not intended to take away the power and obligation of the employee to meet his work with personal judgment and efficiency, but rather to assist by such rules and suggestions as seem necessary and helpful.

Bear in mind that it is up to us to maintain the standard; that it is our duty to *furnish good water every minute* and adequate fire service whenever it is called for; that the manager is depending upon his fellow-workers to do their part, and that he has confidence in them; that in emergencies it is not a question of spending a few dollars in order to get results, for the standard must be maintained regardless of cost.

Fire Alarms (Engineers). The big, general thing to remember is to "play safe." That is, to consider the location of the fire and its probable or possible magnitude, and to promptly take any action that may seem necessary to furnishing an adequate supply of water at proper pressure and maintain the quality of the water; to this end it is better to take much precaution, such as notifying the chief engineer and the assistant chief, calling out an extra fireman or station helper, having fire lighted in extra boilers, getting an extra engine ready, etc., rather than fail in any particular because of lack of having done these things.

In case of a serious fire or general alarm, notify chief engineer and assistant chief engineer; if the fire is at night, notify F. M. Johnson, general foreman (if communication by telephone direct cannot be made,

use Western Union service, both telephones No. 32); get Holly engine warmed up and ready for action; consider the matter of whether there are enough boilers in use and whether extra help is needed in boiler room.

Engine No. 5 for Emergency. Engine No. 5 is the quick-acting emergency and peak-of-load engine. This engine should be put into service at once, in case of any trouble with Allis or Holly. No. 5 can be put under full load, if necessary, *in one minute;* the best way to handle the engine for this quick action is as follows: Both steam valves should always be left hooked up; then, first crack throttle slightly; proceed at once to open water-injection valve; unlatch one steam valve, and go ahead. Each engineer should practice handling the engine until he can safely and surely get under full load in one minute as stated.

Call Bells at Allis. The call bells in lower boiler room and in filter room, with control at Allis engine are intended for use of the engineer when wanting help and not wishing to leave engine; they will sound continuously until stopped.

Call Bell at Observation Sink. This bell may be answered and observation noted by the engineer, filterman, or helper who happens to be nearest at signal. Do not, however, record any observation unless you actually take it. Do not indicate as " O.K." unless water is clear. Smoky water is not satisfactory. For instance, if you record an observation at three o'clock and notice a blank for two-thirty, do not go back and record two-thirty as an observation. Any signals that have been missed, leave them blank; if the observation signal is not operating properly, it should be reported by the engineers to the chief engineer. A signal answered within five minutes after its stated time may be properly recorded.

Report Trouble or Unusual Occurrence. Any particular trouble or unusual occurrence at the plant, in the absence of the chief engineer, should be reported as soon as practicable, by telephone, to Mr. Taylor or Mr. Ranbarger; also, a written report of the matter should be left by the engineer on watch for the chief engineer, before going off duty.

Suspicious Behavior of Engine. Any of the engines developing any trouble or suspicious behavior should promptly be placed under control of the throttle or shut down, as may seem necessary. If placed under the throttle, the engineer should signal filterman or fireman for assistance.

Coppus Blowers and Low-Pressure Alarm. These are to be tested out for operation each week, and recorded on weekly report sheet, with date of test. As a general rule, they will be tested and recorded by the assistant chief; but, if for any reason, he does not do so, the engineer making out weekly report on Friday night will test and record same, signing his name.

Inspecting Recording Gages, etc. The engineer on watch will, immediately after coming on, inspect water-pressure gage on Allis engine, and general condition of all machinery in operation; a little later, he will inspect recording steam-gage and tachometer chart for proper operation,

and also for proper time-setting, and record observation on daily report sheet. Engineers will sign tachometer gages in spaces they are on duty.

In addition to taking revolution counters at midnight for the daily pumpage, the engineer on watch will take the counter on No. 7 at 2.00 A.M. and at 4.00 A.M. each morning, and record the average r.p.m. for the two-hour period on the daily report, also on the graphic chart posted on wall of engine room. Record manometer reading of liquid chlorine apparatus, as provided for on daily report sheet. Take temperature of No. 3 engine room daily, noon and midnight during winter months, and record on weekly report.

Consider the Boiler Plant. The engineer on watch should always know exactly what boilers are in use; what, if any, are banked and held ready for emergency; whether or not any are out for cleaning; in short, have exact knowledge of the entire boiler plant. To this end, it is a rule that each engineer *before taking his watch and before the preceding engineer has left, shall personally inspect* CONDITIONS BOTH UPPER AND LOWER BATTERIES OF BOILER; AND OBSERVE the conditions at every boiler, whether in use or out of use. If a boiler is banked, note the condition of the banked fire, the steam pressure, the height of water in gage glass, the coal supply in car, etc. If any of these are not right, have them corrected as soon as possible. If, in the judgment of the engineer, there are not enough boilers under steam to meet probable demands, he should report to the chief engineer or assistant chief, and if he cannot do this, he should have such changes made as seem necessary or prudent. As a general rule, if the basin is in service and Stirling boiler is in use, one or more of the lower boilers should be under steam; in hot, dry weather, with heavy pumpage, all the boilers, not out for cleaning, should be under steam.

Consider the Fireman. If any change in operation involves more steam use, such as putting additional engines in service, the fireman should receive ample and definite information in time to be prepared for such increase in steam consumption.

Fire-Alarm Reports, etc. A written report on the special blank is to be made of every fire alarm, showing time received, pressure, increased pump speed, etc. In addition, the office should be notified at 7.00 A.M. of all fire alarms received during the preceding night.

Record should be made daily on the weekly report by the engineer who receives the Gamewell alarm test at 12 noon. If test stroke does not come at 12 noon, the chief of the Fire Department should be notified at once.

During cold weather, when the automatic sprinkler pipes in exposed places are empty, the air pressure on same should be recorded twice daily on the weekly report.

[Copy of Letter dated August 15, 1916.]

To Our Employees, — We wish to call your attention to figures furnished us by the Industrial Board regarding the number of eye accidents reported in the state of Indiana in the last ten months; 2 852 men have risked the loss of the sight of one or both eyes; many of them have lost their eyes.

The following is an extract from their report:

"Approximately 10 per cent. of accidents reported during the period of September 1, 1915, to July 1, 1916, were eye cases. On further analysis, these accidents show that they are largely to be classed as preventable accidents. Approximately 20 per cent. of the eye cases arose out of the operation of emery wheels, and the use of goggles would have prevented most of them."

The goggles which we provide remove the risk which you take of serious injury to your eyesight.

Your foremen have been instructed to see that all of the men who require goggles in their work are regularly wearing them. Save yourself from suffering and impaired usefulness by helping us to prevent eye accidents in the plant. This you can do by taking care to wear goggles whenever you are doing work from which an eye accident is likely to result.

THE TERRE HAUTE WATER WORKS CO.

SPECIAL FOR CHIEF ENGINEER.

Sand Catchers. They are to be blow-out the first day of each month, and the conditions found are to be noted on daily and weekly report sheet.

Feed Water Heater. The feed water heater is to be cleaned about the fifteenth day of January, April, July, and October, and the conditions found are to be noted on daily and weekly report sheets.

Cleaning Condensers No. 6 and No. 7. When the condensers are cleaned, the time of cleaning and their conditions should be noted on the daily and weekly report sheets. When convenient, the condenser should be tested for leakage.

Indicator Cards. Indicator cards shall be taken about the fifth day of each month from engines No. 6 and No. 7. A set of cards should be sent to the office.

Coal. Coal cars shall be unloaded by day labor and a record of the cost kept.

River Soundings at Intake. Soundings in river bed along intake line, and extending out to the opening in river, should be taken each summer at low water, and a profile made on basis of low-water mark.

Filter Manifolds. Two filter manifolds of each size shall be kept in stock.

Automatic Sprinklers. Thoroughly inspect automatic sprinklers at the station in November of each year and send written report to the office.

Boiler Feed Pumps. These and the injector should be examined weekly and their condition reported.

Feed Water. Test feed water for soap hardness weekly and report same.

Evaporation Test of Boilers. Boilers to be tested monthly to determine evaporation per lb. of coal; the Stirling and Battery No. 3 to be tested alternately.

Rules and Suggestions for Firemen and Boiler Room Helpers.

For Firemen.

Upon coming on watch, immediately observe steam pressure, water level in boilers, and general conditions. Blow down water from water column to be sure it is working properly.

All coal and ashes are to be weighed, and the time of coal loadings to be entered upon report sheet; the back weighing to be made at end of each shift, and the back weight to be charged to the fireman coming on duty.

After boilers have been cleaned and in service four (4) days, they are to be blown down once each day thereafter at about 8.00 or 9.00 o'clock in the morning. The engineer on watch is to be called at this time, and the extent and method of blowing down is subject to his approval.

Flues to be blown twice each day, on the first and second shift, as soon as convenient after coming on duty.

Any defect in any boiler, steam pipe, feed pump, or any apparatus in the boiler room, should be reported at once to the engineer on watch.

In the event of heavy call for steam, such as a large fire, and the fireman thinks he cannot hold steam with the boilers in use, he should report to the engineer at once.

Firing Methods.

Although it is not intended to lay down any hard-and-fast rule for firing, nor to discourage individual method, if such method can be shown to be better than these, yet it is thought that a very good method of procedure is as follows:

Keep grates fairly clean, and preferably so by the use of shaker grates. (Although it is known that with some coal and conditions of fire, it may be necessary to clean with slice bar and hoe.) Fire at rather frequent intervals, *say seven to ten minutes* — firing at long intervals, say twelve to fifteen minutes, *is not good practice and is* not approved — then manage damper and quantity fired, so that the fires will not burn down dead, and leave air holes at the time of next firing. In general, the least damper opening and draft you can use will be found most economical. When the draft is so great that fire burns down in holes, then heat is lost, simply by heating the air drawn in at such points, and does no good whatever.

It is suggested that the fireman learn to notice the draft gage, just as he observes the steam gage; it will indicate the need of shaking grates, the presence of air holes in fire when they burn too low, etc.

It is recommended that the firing be done as rapidly as possible consistent with the proper spreading of the coal, so that the doors will be open as short a time as practicable; also when about to clean by the slice and draw method, all tools that are to be used should be provided right at hand before beginning to clean, and put away after the cleaning is finished, and the door shut.

Firemen will answer the emergency call bell by reporting at once to the engineer.

If a fire alarm catches you with dirty fires, it is probably best to shake grates, or clean at once, and to do so as quickly as possible, even if you cannot take time to make the cleaning as complete as usual.

It is requested that the firemen, so far as is consistent with their other duties, shall keep the fire room, coal shed, etc., in a neat and tidy condition; this also applies to the toilet room, — always leave it in at least as good condition as you find it.

Firemen will sign their name to the recording steam charts on space that he is on duty.

For Boiler Room Helpers.

Follow our usual practice as to washing and cleaning boilers. As a general thing, about three weeks is a proper length of run; wash out all scale and mud, then pick off all scale that can be gotten at, and wash out again. In the case of the Stirling, the tubes may be turbined each cleaning, or the turbining may be omitted if conditions justify it.

Inspect boiler carefully for defective tubes, tubes needing rolling, bags in shell, or any leaks at any point. Also note the presence or absence of oil or grease in boiler and report to chief engineer. The tubes of tubular boilers should be brushed with wire brush when these boilers are cleaned.

Keep Settings Air Tight.

Boiler setting should be frequently inspected by the candle method for air leaks; fill any cracks or defects with a mixture of asbestos and fire clay.

Baffles.

The condition of baffles should be noted when Stirling boiler is cleaned and repairs made as needed.

Safety in Cleaning Boilers.

The non-return valves provide against return of steam to a boiler that is being cleaned; follow present practice *in seeing that all valves on the feed or blow-off lines that can communicate with any supply of steam or hot water*

are closed. Also, until some other method is provided, wire the wheels of such valves so the valves cannot be opened.

If the cleaning work takes you into a boiler alone, you should always notify the engineer on watch, or other responsible party, of the fact, and of which boiler you are working in.

Fusible Plugs.

When a boiler is being cleaned, the fusible plugs should be inspected and cleaned, both on the outside and inside; if it seems defective, it should be replaced by a new one.

Laboratory.

The methods for carrying on the analyses in the Filtration plant shall, in so far as possible, conform to those prescribed in the Standard Methods of Water Analyses. The latest edition which has been published by the American Public Health Association, bears the date of 1920, and this should be followed until subsequent editions are made. Where daily tests are not carried on in conformity with those prescribed in the Standard Methods, special permission must be secured from the State Board of Health, permitting the use of these deviations.

The daily records as kept at the Filtration plant shall consist of the following determinations:

Chemical and Physical Tests.

Turbidity, raw water.
Alkalinity, raw and filtered water.
Chlorine, filtered water.
Total hardness, filtered water.
Temperature, filtered water.
Color, raw and filtered water.

Bacteriological Determinations.

Number of colonies grown on agar media at body temperature in raw and filtered water.

Tests for B. coli by noting gas formation in fermentation tubes, raw and filtered water. These to be confirmed where gas appears.

Chemical and Physical Tests.

Turbidity. The turbidity shall, as a rule, be determined by means of the Jackson turbidimeter. The sample, as collected, shall be representative of that entering the plant. With the low-service pump in operation, and the alum solution fed under pressure, a representative sample can be col-

lected at the discharge of this pump, but back of the point where the alum is fed. When the alum solution is fed by gravity, the sample should be collected at the west side of the screen chamber by means of a small pump which has been provided for this purpose. As previously stated, care should be taken to collect, in each case, a representative sample, irrespective of the point at which it might be taken. When the river is rising, turbidity readings shall be taken every two hours.

Alkalinity. The determination of alkalinity shall be carried on in accordance with the instructions given on page 35 of the Standard Methods. If the raw water carries a large amount of matter in suspension, it is well to remove this before taking the alkalinity, in order that a better end point can be obtained.

Chlorine. The determination of chlorides in the water shall be carried on in accordance with the method outlined on page 41 of the Standard Methods of Water Analyses.

Total Hardness. In connection with the determination of total hardness in the filtered water, it is suggested that this be estimated by what is commonly known as the soda re-agent method, page 34 of Standard Methods, and not by the soap method as formerly used. The soap test is merely a record of the soap-destroying power of a water. The results are only approximate, and at best convey but little useful information. Where an analysis of the water has been made and the character well known, the soap test may be useful as a rapid means of determining any variations; but beyond this it does not furnish much real information.

In the tests for total hardness, the calcium and magnesium should each be determined separately and the results recorded. As a rapid method for determining the magnesium contents, the following is suggested:

Use 200 c.c. sample of filtered water; convert the carbonate hardness into sulphate hardness by the addition of N/10 or N/50 sulphuric acid, using methyl orange as an indicator. Place over bunsen burner and evaporate to 100 c.c. Add an excess of saturated solution of calcium hydrate or slaked lime. Immediately upon the addition of the hydrate of lime, the burner should be removed and the contents allowed to cool gradually. Filter and titrate the filtrate for excess alkalinity by means of standard sulphuric acid.

A sample of distilled water should be run as a blank at the time this determination is made. After boiling long enough to expel all free CO_2, equal amounts of the saturated lime solution are to be added to the filtered and distilled waters. The magnesium is then determined by differences.

The chief point to be observed in connection with the determination of magnesium is the greatly decreased solubility of calcium hydrate in the hot, over that when cool. As a guide in this respect, the following table has been prepared:

LIME SOLUBILITY.

32°	112 grains per gal.
40°	107 grains per gal.
50°	103 grains per gal.
60°	98 grains per gal.
70°	94 grains per gal.
80°	91 grains per gal.
90°	87 grains per gal.
100°	84 grains per gal.
140°	70 grains per gal.
180°	54 grains per gal.
212°	44 grains per gal.

The results obtained should be calculated as magnesium in terms of calcium carbonate. The calcium can then be estimated by taking the difference between the total hardness and the magnesium hardness. Although this means of determining the calcium is not absolutely correct, yet the error is very small and is sufficiently accurate for our determinations.

The determination of total hardness by means of the soap method can also be carried on if it is thought best as a general guide in the laboratory work. Results for total hardness are to be recorded in both grains per gallon and parts per million.

Chemicals for Softening. With the alkalinity, permanent hardness and magnesium hardness determined as p.p.m. in terms of $CaCO_3$ and the free carbon dioxide determined as CO_2, the chemicals required for softening can be estimated by applying the following factors:

For each p.p.m. of alkalinity as $CaCO_3$, it will require 0.0068 lb. of $Ca(OH)_2$ per 1 000 gal. of water treated.

For each p.p.m. of permanent hardness determined as $CaCO_3$, it will require 0.0113 lb. of Na_2CO_3 per 1 000 gal. treated.

For each p.p.m. of magnesium determined as $CaCO_3$, it will require 0.0068 lb. of $Ca(OH)_2$ per 1 000 gal. of water treated.

For each p.p.m. of free CO_2 determined as CO_2, it will require 0.0154 lb. of $Ca(OH)_2$ per 1 000 gal. of water treated.

The above factors have been determined upon the following strength of chemicals:

$Ca(OH)_2$ is assumed to contain 68 per cent. CaO. This is 90 per cent. of the theoretical strength.

Na_2CO_3 is assumed to be 98 per cent. pure.

Temperature. (Filtered water.) The temperature can be taken at the sampling sink, allowing the thermometer to stand in a freshly-drawn glass of water for at least three or four minutes.

Color. (Raw and filtered.) The color shall be determined by a comparison with glass disks, as recorded on page 10 of the Standard Methods.

Bacteriological Determinations.

In the bacteriological determinations, extreme care should be taken in getting a representative sample, also in seeing that all equipment is carefully sterilized, the media properly manufactured, and the technique employed conforms with the best practice. These points are covered in the Standard Methods and should be followed.

Colonies on Agar Media. The agar media shall be prepared in accordance with the instructions given on page 96 of the Standard Methods. With the approval of the State Board of Health, a dehydrated media prepared by the Digestive Ferment Company, of Detroit, Mich., can be used. At least one plate from the filtered and one plate from the river supply shall be made daily, and results recorded as number of colonies per cubic centimeter. In the event results in the laboratory are not up to the standard prescribed by the United States Public Health Service for water supplies on common carriers, viz., below 100 per c.c., it may be necessary to increase the number of plates made daily, and in addition take individual samples from each filter in service.

Tests for B. Coli. The tests for the presence of members of the B. coli group shall, in general, conform to that outlined on page 100 of the Standard Methods.* There have been two slight deviations from the method as given; namely, a reduction in the percentage of lactose in the endos media from 1 per cent. to ½ of 1 per cent., and increasing the amount of fuchsin. It has been found in connection with our laboratory work that a fuchsin solution, having a strength of approximately four times that given in the Standard Methods, gives us the best confirmatory results. These changes noted were made at the instigation of Mr. L. R. Taylor, water chemist and bacteriologist of the State Board of Health, after a two days' inspection had been made by him of the results obtained at our plant, July 9 and 10, 1919. This change was later confirmed by Mr. Taylor, in a letter written to Mr. Gwinn under date of November 4, 1919. The interpretation of results shall be made in accordance with the Standard Methods.

As a daily routine, it is suggested that five 10 c.c. samples of the filtered water and 1 c.c. sample of the raw water be planted in the lactose broth solution. As a guide in determining the sanitary qualities of the water supply, the results obtained should conform with those prescribed by the United States Public Health Service for water supplies furnished on common carriers; that is, out of five 10 c.c. samples planted in lactose broth, not more than one shall show positive confirmatory tests for B. coli.

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* The 1920 edition of the Standard Methods adopted the ½ of 1 per cent. lactose as the standard liquid media, and also increased the strength of the fuchsin solution to approximately that used in our laboratory.

Miscellaneous Tests.

The determination, as previously stated, shall be made daily. In addition to this, other determinations are to be made at less frequent intervals. These shall consist of —

Total residue and complete mineral analysis.
Free carbon dioxide.
Analysis of the filter alum as delivered.
Hardness in the boiler feed water.
Salts present in the boiler water, etc.

In addition to these, and especially during the summer months and at seasons of the year when micro-organic growths are most likely to be present in the water, microscopic examinations shall be made.

Total Residue and Mineral Analysis. The total residue on evaporation shall be determined in accordance with the method given on page 29 of the Standard Methods. Having obtained this, a complete mineral analysis should be made once each month, setting forth the total solids in solution, — silica, iron, aluminum, calcium, magnesium, sulphates, carbonates, chlorides, etc., — all as outlined on page 56 of the Standard Methods under the caption, "Mineral Analysis."

If a composite sample can be made, covering the entire month, by collecting 100 c.c. of water from each day's supply without a precipitation occurring of the soluble salts, during this period, this composite sample should be used in making the monthly mineral analysis. If a precipitation does occur, it is suggested that a composite sample be made covering a shorter period, this to be reduced to such length of time that no precipitation of the soluble salts will occur. The average, maximum and minimum river stage and chemicals fed shall be recorded, with the results of the mineral analysis.

Free Carbon Dioxide. The determination of free carbon dioxide shall be made at least once a month, and in accordance with the method given on page 40 of Standard Methods.

Filter Alum. As a general proposition, it is suggested that an analysis be made of each carload of alum delivered at the plant. This to determine in general the insoluble matter, aluminum oxide, ferric oxide, basicity ratio, and, if present, free sulphuric acid. The routine for such analysis is given on pages 77 and 78 of Standard Methods. A representative sample for such analysis can best be taken at the time the car is approximately half unloaded. In reporting results, car number, initial, and date of delivery should be included.

Feed Water. In the general instructions, under the caption, "Special for Chief Engineer," the hardness in the feed water as delivered to the boilers is to be determined weekly. Although it is suggested that the

soap method be used in connection with these analyses, more complete results could be obtained by determining the calcium and magnesium contents separately, as noted under Total Hardness. In addition to the hardness, observation should be made for the presence of oil. This could be determined quantitatively by noting the ether soluble matter, as given on page 69 of the Standard Methods.

Boiler Water. In testing the concentration of the different solutions in the boiler water, care should be taken in securing a representative sample. If this is drawn from the gage glass, the valve at the top of the glass should be closed in order to prevent steam from passing down into the sample. With the upper valve closed, the water should be drawn very gradually, in order that evaporation will not take place and thus increase the amount of the soluble salts present. It is the soluble salts in boiler waters that usually cause corrosion and pitting. In general, determinations should be made of the chlorides, sulphates, nitrates, carbonates, and silicates.

The metal magnesia offers the most deleterious action on iron, and especially if this occurs in the form of a chloride. It is, therefore, suggested that determinations, if possible, should be made to ascertain the manner in which the magnesium is combined with the different acids. The frequency and extent to which a boiler should be blown down should depend upon the concentration of the solution as shown by an analysis of this kind.

Microscopic Examinations. Micro-organisms are to be determined during the summer months, and at seasons of the year when these occur the character and amount of these different growths, to determine the manner in which the microscopic tests are to be made. The presence of these organisms is not to be looked upon as deleterious to health, yet, from an æsthetic standpoint, it is often the means of causing a great deal of dissatisfaction. At times, when such organisms are present, the determinations for nitrogen, dissolved oxygen, oxygen consumed, etc., might be of assistance in identifying the different genera. A full and complete record, with sketches and descriptions, should be recorded at the time these examinations are made. Whipple's *Microscopy of Water* and Ward and Whipple's *Fresh Water Biology* are to be used as a guide in these determinations.

Filtermen.

Filtermen will attend to their usual duties, as they have been instructed, and such special work as they may be given.

Filtermen, immediately upon coming on watch, shall inspect the condition of the alum tanks and note whether or not the proper feed is being maintained. Following this, they shall also inspect the basin when it is in use and see if the water is being properly treated and coagulated. If chlorine cell is in use, then inspect condition at the cell as soon as practicable after the other matters above have been attended to.

Filterman on watch will, soon after coming on, inspect recording water pressure gages for operation and time setting, and record same on daily half hourly report sheet. Filtermen will sign name to water-pressure charts in space that he is on duty, also on his daily report sheet.

The filtermen will usually be informed by the chief eningeer, by a suitable mark on the Chemical Feed chart, of the desired rate of alum feed and when the basin is not in use; the rate shall be made to correspond with the changes in speed of the Allis engine, by changing the alum feed plugs as may be necessary, noting the plug changes on daily report sheet. When the basin is in use, the rate of alum feed may be given, or it may be left to the judgment of the filterman; usually, in a changing river, it is not practicable to fix the alum rate, but must be changed as necessary to get a suitable coagulation. In the absence of definite instructions, or a changing river, try to use enough to get good water and, on the other hand, not to waste any alum. The practice of taking a glass of water as the water enters basin and setting it down while observing the basin, then looking at the glass again, is a valuable help in determining suitable coagulation.

If the river is changing when basin is off, the conditions should be watched closely and basin put on at about 50 to 60 turbidity.

Filtermen will keep filter plant and basin neat and clean; upon a fire alarm or call bell signal, they will report to the engineer promptly, and assist in any matter as the engineer may direct.

Any stoppage of alum or chlorine feed, when supposed to be in use, shall be noted on the filterman's report sheet with the time and duration of such stoppage. In addition to reading the gage on the alum tank at time of changing tank, record readings hourly.

Washing Filters. In starting to wash filters, the wash valve should be opened very slowly, taking about five minutes to get the full rate of wash. The length of time to be used in washing the filters will be given from time to time by the chief engineer, and shall remain the same until changed by definite instructions. Ordinarily, small filters should be washed about ten minutes and large filters about fifteen minutes.

Vertical Filters, No. 1 to No. 12, Inc. In washing the vertical filters, the wash valve (4 in.) is to be used wide open, as the proper rate of flow is maintained by other valves at each end of the wash line. After washing and filling, the proper rate of flow is obtained by opening the inlet valve four turns.

Horizontal Filters, No. 17 to No. 22, Inc. When washing these filters, open valve four or five turns, modifying this if necessary by observing speed of pumping engine, and maintain a uniform rate of washing. After washing and filling, regulate the rate of filtration by opening inlet valve five turns.

Horizontal Filters, No. 13 to No. 16, Inc. Same thing will apply, with the exception of using only three turns of wash valve.

After Washing Filters. Every time each filter is washed, the effluent should be turned into the sewer for about three minutes before turning into distribution system. Each time after washing filter (and before turning on) examine effluent within a few minutes after turning in, by filling pint Mason jars. These jars are to be kept for observation by chief engineer.

If, during the filter washing, any unusual behavior of any filter is noticed, indicating that something is wrong with it, the filter should be cut out of service and reported to the day man for examination.

Turbidity. The turbidity in the raw water is taken daily by the chemist in the laboratory at about 9.00 A.M. Where the condition of the water is not changing rapidly and the turbidity does not exceed 100, the observation made at that time can be used as a guide for feeding chemicals, and additional tests by the filtermen will not be necessary. When, however, the turbidity is in excess of 100, and especially if it is subject to rapid changes, each filterman is to make at least one determination for turbidity during his watch, and the results are to be recorded upon the filtermen's daily report sheets. During such periods, samples are to be collected at the following places:

(1) The raw water at the sink, if this is found to be representative.

(2) The north end of the settling basin, just east of the center partition wall and before passing to the west side of the settling basin; and

(3) The settled water at the sink after it has passed through the settling basin and before going to the filters.

The Jackson turbidimeter (candle) is to be used in taking turbidities where these exceed 25 p.p.m. If the turbidity falls below this amount, silica standards are to be used.

[Forms referred to in this paper are on file at the office of the New England Water Works Association.]

Discussion.

Mr. J. M. Diven.* What automatic sprinklers are referred to?

Mr. Gwinn. Those in our own plant. I should say that we did not care to burn down, and we don't carry very much insurance. We put automatic sprinklers all through the engine room and fire room, so that if we ever did have a fire we would have a chance to take care of it. All automatic sprinkler lines are supplied by a meter, with the exception of our own station. We have none on that.

Mr. William W. Brush.† How much interest do you find that the men take in the instructions? Do you find that they are interested in reading them, or is it necessary to continually remind them to enter their names in the spaces for the record?

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* Superintendent, Water Works, Troy, N. Y.

† Deputy Chief Engineer, Bureau of Water Supply, New York.

Mr. Gwinn. I have not yet found it necessary to suggest to any of the men to read it. They know that the book is lying on the desk and that I am there nearly every day. So some time before the end of the month they will read it. They are doing that on our time, anyhow, and they are taking interest in their work. There is no doubt about that. We have a splendid force of men. We have a little box up there, by the way, marked for suggestions, so that if they have any suggestions they can put them in there; our relations are such that they do not have any hesitation in telling me what they want to tell me. They do not stand back and hesitate about it.

Mr. Brush. Did you have any trouble during the war period — with men leaving you?

Mr. Gwinn. Oh, yes.

Mr. Brush. What percentage?

Mr. Gwinn. Probably about twenty-five per cent., but we made up with older men who took the place of the younger men.

Mr. J. S. Dunwoody.* Another question regarding the advisability of furnishing men with reading matter. At our plant the chief engineer has been after me of late in regard to engineers and oilers spending too much time reading and allowing their work to drag, and especially on the night shifts. They bury their faces in the newspapers and forget that there is such a thing as a pump running in the plant. I rather hesitated to take away the papers from the engineering force of the station and have been supplying of late technical papers, such as *Power Plant Engineering*, *Machinery*, and various other periodicals that are published with reference to helping in their line of work. I do find that they read those magazines to a considerable extent, but I will say that I have come to the conclusion that newspapers should be excluded from the engine room. If Mr. Gwinn has had any definite experience along that line of reading, I should like to hear of it.

Mr. Gwinn. No, we furnish the daily papers for them, too. They want to keep posted on what is going on. We have the library of the American Correspondence School, the Power library and other books of the kind that the men might be interested in.

I want to make one statement before we go any further: Half the lies they tell on the Irish are not true. [*Laughter.*]

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* Superintendent, Filtration, Erie, Pa.

EFFECT OF SMALL GATE OR VALVE IN LARGER PIPE LINE.

BY T. E. LALLY.*

[*Read September 8, 1920.*]

The loss of pressure caused by placing of a gate or valve of smaller diameter, with suitable reducer and increaser, in a pipe line of larger diameter, will be treated in this paper.

The writer has not found any extensive tests recorded on this subject, and such information as has been obtained may prove of value to engineers and superintendents having to do with the construction and maintenance of water systems. The statement has often been made that, if a smaller valve could be placed in the line without too much pressure loss, time could be saved in case of a break, and in Boston it is very hard — almost impossible — to put a line size gate in any of the feeder lines, because of the crowded condition of the underground street area by public-service equipment. Therefore it was thought desirable to determine, if possible, the actual loss due to a 12-in. gate with a reducer and an increaser in a 16-in. line.

The tests were made with a 12-in. gate placed between two 16 x 12-in. reducers in a 16-in. line. The gate and reducers were of the Boston Water Works standard. No selection was made and no extra care was taken with the castings. In fact, they were simply taken from stock and placed in the line. The test line was prepared by cutting in a 12-in. gate on the 30-in. low-pressure feeder line in Southampton Street west of the creek that is all that is left of the upper South Bay. This gate was extended as a 12-in. line to the street line, where it was brought to the surface by easy curves and continued on blocking, so that the bottom of the pipe was about 6 in. from the ground for 26 ft. The line was extended by putting in a 12 x 16 increaser, and then 16-in. pipe for a 23 ft., when a 16 x 12 reducer and a 12-in. gate with a 12 x 16 increaser were set. The pipe was then 16 in. for a $13\frac{1}{2}$ ft., where a 16 x 12 reducer and a 12-in. gate were introduced. Then the line was continued with 12-in. pipe, 21 ft. to a curve and a special casting, with a flange, increasing to 14 in. internal diameter. To this casting was attached a bronze forebay, to which it was possible to attach nozzles from 8 in. on the forebay down to $2\frac{1}{2}$ in.

The 16-in. pipe was bored, just outside each reducer, by $\frac{1}{8}$-in. holes through the walls of the pipe 120 degrees apart, with one hole on the vertical diameter. These holes were then bored out part way through the pipe and tapped for $\frac{1}{4}$-in. iron pipe. Care was taken to remove any bur on

* Assistant Engineer, Boston Water Works.

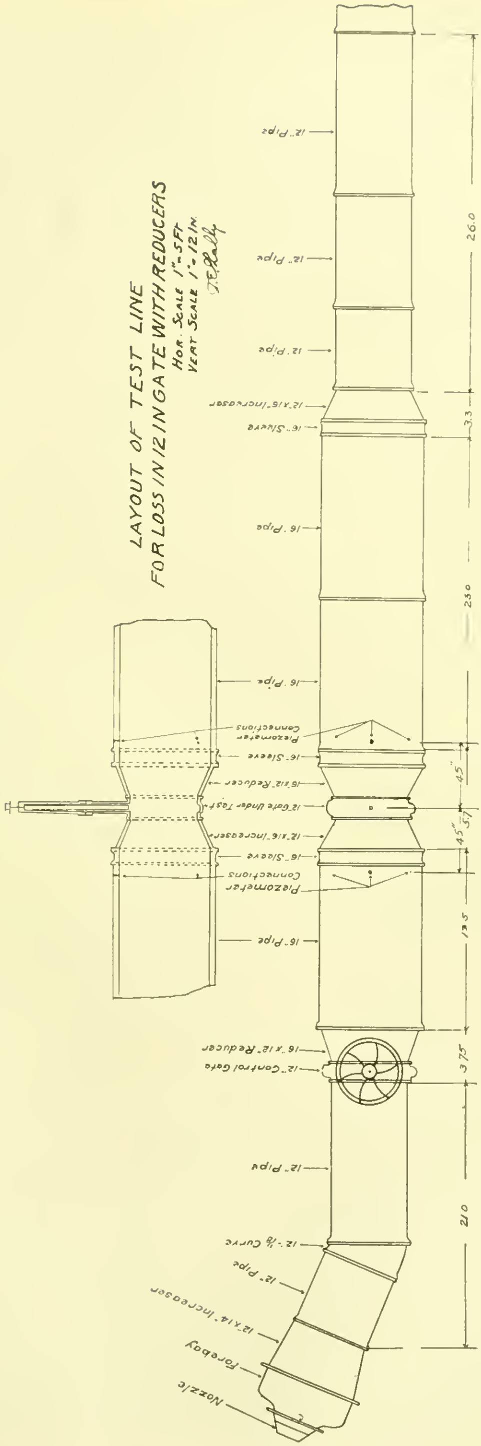

LAYOUT OF TEST LINE
FOR LOSS IN 12 IN GATE WITH REDUCERS
HOR. SCALE 1"=5 FT
VERT SCALE 1"=12 IN
12" Pipe
12" Pipe
12" Pipe
12"x16" Increaser
16" Sleeve
16" Pipe
16" Pipe
Piezometer Connections
16" Sleeve
16"x12" Reducer
12" Gate Under Test
12"x16" Increaser
16" Sleeve
Piezometer Connections
16" Pipe
16"x12" Reducer
12" Control Gate
12" Pipe
12"-1/8 Curve
12" Pipe
12"x14" Increaser
Forebay
Nozzle
26.0
3.3
23.0
4.5"
5.7
4.5"
13.5
3.75
21.0

FIG. 1.

the interior of the pipe and to see that the holes were on radial lines and at right angles to the pipe. As will be noted, there was no chance for the $\frac{1}{4}$-in. pipe to enter the waterway and consequently no disturbance was caused by these connections. Pieces of $\frac{1}{2}$-in. hose were attached to the lower $\frac{1}{4}$-in. pipes and both were brought together into a $\frac{1}{4}$-in. cross at the top holes. This cross was connected by $\frac{1}{2}$-in. hose to a valve board with a number of $\frac{1}{4}$-in. valves on it, which were connected to a long U-tube with a suitably graduated scale. Both pipes were measured at these holes and found to be 16.01 and 16.03 in. It was not considered that this difference would have enough effect on the results to notice, and both pipes were considered of the same diameter and used as piezometer rings.

Carbon tetrachloride was used having a specific gravity of 1.60, to act as an indicator in the U-tube. Mercury might have been used, but, as the loss expected was small and the specific gravity of mercury is about 13.56, it will be seen that the carbon tetrachloride is twenty-one times more sensitive, and small differences in pressure give greater deflections in the U-tube. The tube and lines of hose were provided with blow-off cocks, and care was taken to lead the water upward to these so that air in the lines could be blown out. It will be seen from the sketch of the line that the difference in pressure, before entering the reducer and after leaving the increaser attached to the 12-in. gate, was caused to be shown in the U-tube, and by the use of a factor explained later the actual loss in pounds was arrived at.

The forebay and nozzles were kindly loaned by the engineers of the Factory Mutuals Insurance Company. The forebay was bored on the ends of two diameters at right angles to each other, and these holes were connected to gage fittings on the top by bronze tubes. The interior is of piston finish, as are the nozzles. The reducing portion of the forebay, from 14 to 8 in., was very gradual. The 8 reduces to 6 in. by a bolted fitting. The other reductions were made by screw nozzles, reducing one to another by inches, so there was a gradual reduction from the 14-in. forebay to the $2\frac{1}{2}$-in. nozzle without any breaks in the interior wall of the waterway.

Flow was controlled by the last 12-in. gate, thereby keeping the gate under test always full of water. This control gate was operated by a hand wheel, and any pressure desired could be obtained in the forebay within the range of the nozzle used. From pressure readings on the forebay gage, after corrections for the height of the gage over the center of the nozzle, the discharge was calculated by the use of Freeman's formula. Readings on the gage and the difference on the U-tube were taken simultaneously, and from these readings it was possible to know the discharge and the loss for any flow up to the capacity of the nozzle. When the pressure in the forebay did not increase on the wider opening of the control gate, it was assumed that the capacity of the nozzle had been reached. The next larger nozzle was then used, and by the control gate the full

range of the discharge was run. In this way discharges from 700 g.p.m. to over 10 000 g.p.m. were obtained, and losses through the gate were measured. During all these runs the gate under test was always wide open, as the object aimed at was the losses in the gate and reducers, as if they were in a system supplying water, therefore the gate would be full open.

The available static pressure on the line at the gate being tested was 57 lb. It must not be assumed that the results here given are to be applied to every gate of this size. As the writer noted previously, this test

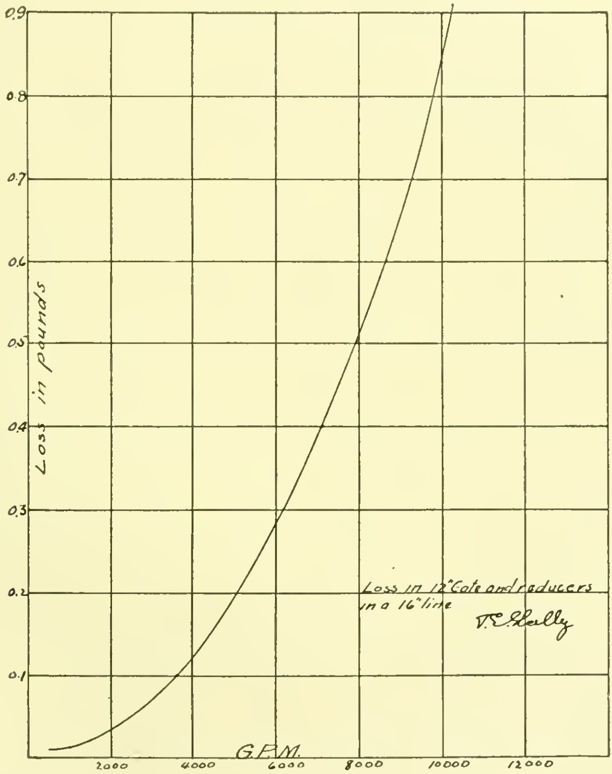


FIG. 2.

was on a standard gate of the Boston Water Works, and tests on gates of other design would probably give slightly different results. This gate is considered of good design. There are no obstructions in the waterway; the valve or plug and stem are out of the waterway when full open. A section through the gate on the line of flow is shown. As stated before, this was a stock gate, not one made for the test.

The results of the tests are plotted on cross-section paper. It will be seen that the curve does not follow the mathematical curve for losses. This rule, that "the loss in friction is as the square of the discharge," while near enough for practical purposes, does not obtain in these tests.

This caused a feeling that there was something wrong in the first test, and other tests were run, special care being taken to get the air all out of the lines and the connections tight in every way. The results agreed with the first, and the writer began to look for the reason.

It was found that the plotting of the curve, on a large scale for the losses, caused the difference to stand out, and while it was small it looked large on the plot, and being there caused further investigation. As far as the writer knows, losses due to such large flows through a gate of this size have never been recorded. Then, taking Freeman's paper "Hydraulics of Fire Streams," and analyzing some of the tabulated data, it was found that the loss did not vary as the square, but ranged from 1.775 to 1.92, and Freeman in the same paper (p. 338) says that his results do show "that there is a slight divergence from the law." Referring to Flinn, Weston, and Bogert Waterworks Handbook, 1916 edition, page 560, it reads: "Textbooks make the general statement that the friction head in pipes varies nearly as the square of the velocity. Researches indicate that this exponent varies between 1.75 and 2.00."

A. V. Saph and E. W. Schoder, A.T.S.C.E., Vol. 51, 1903, presented a paper on investigation of the losses in pipes from a velocity of a fraction of a foot per second to 44 ft. per second, and their plottings show different exponents for different kinds of pipe, but the exponent is evidently the same for each size, of the various kinds, with different velocities.

The velocities, in the 12-in. gate under test, varied from 1.3 ft. per second discharging 750 g.p.m. to 34 ft. per second at 12 000 g.p.m. With these references in view, the writer felt that the fact that the curve did not agree with the curve of the squares was not due to errors in the methods or the gage connections or readings.

The 14-in. forebay used in these tests slowed up the velocity of the water before entering the nozzles, and the gage on the forebay showed a very steady pressure, there being a noticeable absence of the vibrations, such as are shown in the piezometer tubes placed at the base of play pipes in flow tests made by him through lines of fire hose. The writer first figured the data with seven-place logarithms, and finding the results could be obtained by the slide rule to two places of decimals, used the rule for the greater part of the calculations. As we are dealing with hundredths of a pound loss, with a maximum of about a pound total loss, it did not seem necessary to resort to the longer method.

In calculating the discharge, from the pressures in the forebay, a correction was made for the elevation of the spring gage over the center of the nozzle. The discharge of 4 lb. and 64 lb. were calculated and plotted on a large sheet of logarithmatic tracing paper, making a straight line between, from which, with any pressure on the forebay with the size of nozzle discharging, the discharge was read off on the paper. This was done for each size of nozzle used, and greatly facilitated getting the data from which the curves were made.

In using carbon tetrachloride as an indicator, as the writer stated before, the deflection or difference in height of the tops of the column of fluid in the arms of the U-tube is about twenty-one times as great as it would be if mercury were used. This, however, introduces a condition that requires attention.

In a difference of 1 lb., using mercury, the measure of this in inches is about $2\frac{1}{32}$ in. With tetrachloride, being only 1.60 heavier than water, the difference ought to be about $17\frac{1}{4}$ in. as the weight of, or pressure due to, a head of water $27\frac{3}{4}$ in. in height is 1 lb. However, as the fluid drops in one arm it rises in the other, and water takes its place on the pressure side until a balance is obtained. Now, instead of reading the true difference in pressure, we have a column of water on one side greater in height than that on the other, or low-pressure arm, by the difference in height of the tops of the fluid in the tube. The weight of this column of water must be subtracted from the indicated difference in pressure to arrive at the true difference. The difference, when using mercury, is slightly over 2 in. for 1 lb. difference in pressure, and with mercury, under ordinary circumstances and unless dealing with large losses, may be neglected; but with such a height of water column, when using an indicator of such low specific gravity, a correction must be made for each difference in pressure.

The writer found that a factor could be obtained, by the use of which the true pressure could be arrived at with very little work. As the scale on the U-tube used by the writer was graduated for use of mercury, it was found that by multiplying the reading on the mercury scale for pounds and tenths of pounds by 0.044 the true difference in pressure for the specific gravity of 1.60 was obtained. This factor would change if the specific gravity of the indicating fluid was changed. With a tube that would give a difference of pressure of 30 lb. mercury, or about 6 ft. long, the tetrachloride would give a difference of pressure of about 1.32 lb. However, as a small loss was looked for, this indicator proved satisfactory.

The writer found that great care had to be exercised in the use of this indicator. The first runs were marred by irregularities in the readings, which were found to be caused by air in the rubber-hose connections. After having found the cause, great care was taken to keep the hose free from air, and the results began to agree one test with another. Tests were run on six different days, and the writer feels that the results given are very close to the actual conditions.

With a flow of 500 g.p.m. the loss was 0.01 lb.; at 1 000 g.p.m. it was scarcely larger; at 2 000 g.p.m. it was about 0.03 lb.; 4 000 g.p.m. showed about 0.12 lb.; 5 000 g.p.m. about 0.20 lb.; 6 000 g.p.m. gave 0.29 lb.; 8 000 g.p.m. about 0.51 lb.; 10 200 g.p.m. gave 0.92 lb.

These losses make a curve, when plotted to suitable scale, and show clearly that we may place this smaller size gate in our pipe lines and not lose over one pound pressure, with a discharge which I think would seldom be required even in a 16-in. line.

The writer thinks that, in addition to the information already given, it would not be out of place to add a little in another line, that he obtained while making these tests.

The indicator was drained out from the U-tube and mercury substituted. With the same set-up of the U-tube and a 5-in. nozzle on the forebay the control gate was opened full, getting a discharge of about 5 000 g.p.m. The writer then caused the gate under test to be started down, carefully noting the turns taken and watching the U-tube until the mercury showed one pound loss. It was found that the mercury gave 0.2 lb. loss with this discharge, with the gate open full as it had been when the flow tests were made. When the gate had been closed nine turns

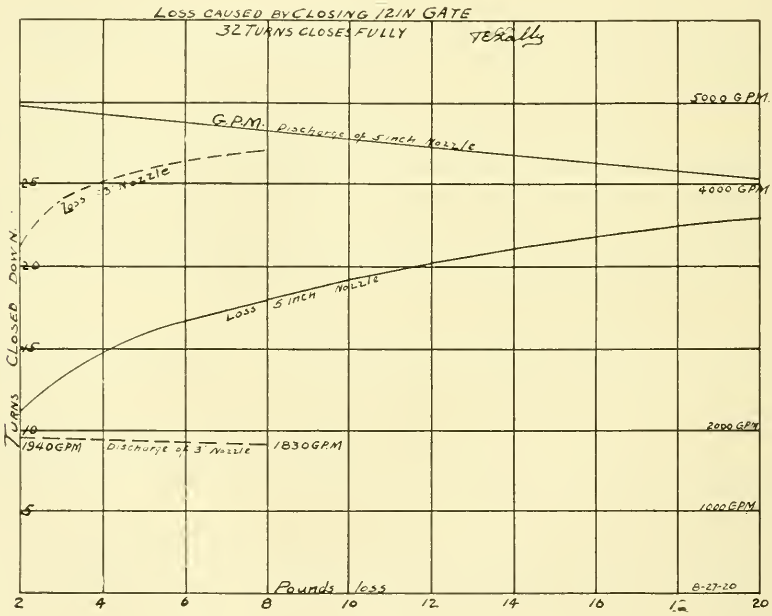


FIG. 3.

the loss was 1 lb.; $11\frac{1}{4}$ turns gave 2.0 lb.; $13\frac{1}{2}$ gave 3.0 lb. loss; $14\frac{1}{2}$ gave 4.0 lb. loss; 18 turns down gave 8.0 lb. loss; 21 turns gave 14.0 lb. loss; 22 turns gave 18.0 lb. loss; $22\frac{1}{2}$ turns gave 20.0 lb. loss.

This was the limit of the mercury column, and no further losses were noted. This gate required 32 turns to close it fully. During this closing period the discharge fell from 5 000 g.p.m. to 4 050 g.p.m.

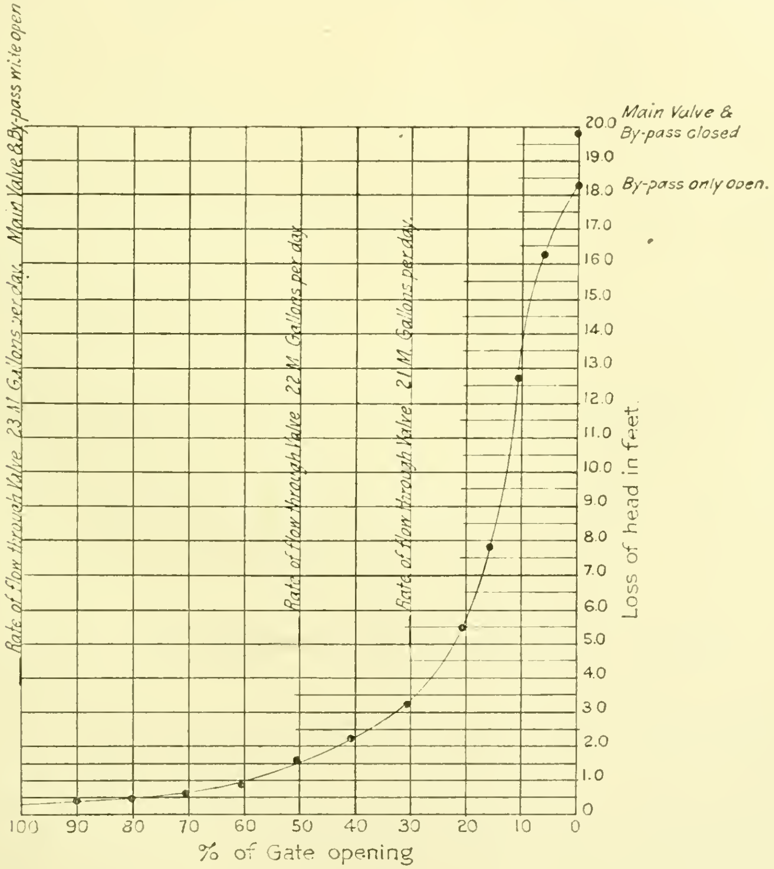
The test was then run, using a 3-in. nozzle to get a smaller discharge. The results would probably be more in line with the requirements of a small system. It was found that this gate was passing 1 940 g.p.m. full open with the 3-in. nozzle. The gate was closed down 20 turns before the pressure fell one pound, and the discharge was then 1 940 g.p.m. Twenty-

five turns gave a loss of 4.0 lb. with a discharge of 1 910 g.p.m.; 27 turns gave a loss of 8.0 lb. with a discharge of 1 830 g.p.m.

The gate was not closed down further, as it was considered that there was little likelihood that one would care to throttle a gate beyond this distance. The writer gives this data as a help to those who, for reasons you all know, would wish to keep water on a line and still do not want the gate wide open, in case anything should "let go" beyond.

Discussion.

Samuel E. Killam.* In 1913, while hydraulic measurements were being made to determine the friction loss in the pipe lines on the Weston



Aqueduct Supply Mains on the Metropolitan water supply for Boston, an opportunity was afforded to observe the loss of head through a 36-in. valve on one of the mains. The total length between the piezometers was

* Superintendent, Metropolitan Water Works.

40 ft., which included a long and a short 60-in. to 36-in. reducer, a 60-in. manhole pipe, a 76-in. to 60-in. reducer, 5 ft. of 60-in. pipe, and 2 ft. of 76-in. pipe.

Gate Opening.	Loss of Head. (Ft. of Water.)
Gate and by-pass open	0.35
Closed 30 turns	0.39
Closed 60 turns	0.49
Closed 90 turns	0.63
Closed 120 turns	0.88
Closed 150 turns	1.65
Closed 180 turns	2.27
Closed 210 turns	3.28
Closed 240 turns	5.50
Closed 255 turns	7.80
Closed 270 turns	12.70
Closed 285 turns	16.30
Closed 303 turns	18.30
Gate and by-pass closed	19.80

These results are shown graphically on the diagram (page 309), from which it will be seen that the flow through the valve was at the rate of 23 million gallons per day when the test was started and, when the main valve was closed 50 per cent. of the area of the opening, the flow was at the rate of 22 million gallons per day, with a loss of head of only 1.65 ft. This loss increased rapidly as the valve was closed beyond this point.

W. C. Hawley.* Mr. President: Last winter a gentleman presented an excellent paper before the Engineers' Society of Western Pennsylvania, on mechanically operated valves, — that is, valves on which electric motors are mounted which will open or close the valve, the electric current being switched on to the motor from a distant point. He explained conditions in steam plants and the difficulty of getting to the valves on account of their inaccessibility, and how in case of the bursting of a steam main it was possible, by pushing a button, to start the motor and close the steam valve in a few seconds. He was enthusiastic on this proposition of the quick closing of a steam valve in case of an emergency in a power house, and we can readily appreciate the great value of his device, which is in successful operation in many power plants. He went on to show what a splendid thing it would be to have the valves in a large water-works distribution system equipped with motors, so that instead of taking half an hour or more it would only be necessary to push a button and the valve would be closed quickly, and the loss to property and contents by water flowing from the break would be materially reduced. I asked him if he had considered the possibility of further bursting of the mains by water hammer, due to the quick closing of the valve. He claimed that if necessary the valve could be closed at a rate of three inches per minute. My experience has been that in closing a valve, when the gate or gates are

* Engineer and General Superintendent, Pennsylvania Water Company.

nearly seated so as to materially obstruct the flow of water, it is necessary to continue closing the valve very slowly, — generally to take a turn or part of a turn on the wrench and then wait for a few seconds. Three inches per minute would cause a serious water hammer if there were any considerable pressure.

Henry A. Symonds.* This reminds me of a curious case of reduction in the available cross-section of a pipe, and while the data are not as valuable as they might be had there been means for accurate observations, they are of some interest.

In a pipe line about four miles long, conveying water from an upper to a lower reservoir, supplying a population of about five thousand people and several manufacturing plants, there was occasion to lay a by-pass and pump through the by-pass for a time while a section of about 800 ft. was out of service.

One end of this pipe, which was 10-in., was plugged with an 8-in. plug in the spigot end of the 10-in. pipe.

By letting out the water in the section below this plugged end, and burning out the plug by fire under the pipe, a vacuum was created causing the plug to be drawn into the pipe line a considerable distance.

As it was during an intensive cold period in the winter, and the ground was frozen to a great depth, it was rather a frightful situation for those responsible for the water supply.

However, before orders could be given, the workmen had connected up the pipe and turned the water through the main section. There had been no margin above the demands of the town, and it seemed inevitable that there would be trouble in a day or two, when the lower reservoir was depleted.

To the writer's surprise there seemed to be no measurable reduction in the discharge of the pipe line and it seemed evident that there had been some mistake as to the plug being in the line.

After about a week, a warm spell occurred, and an effort was made to locate the plug, which was successful. The plug was slightly tilted, appeared to close the pipe line practically off, and had to be removed with a sledge hammer.

This instance seems to illustrate the fact that a marked contraction in the cross-section is possible under certain conditions without appreciable loss in volume of discharge.

C. W. Sherman.† It has been pretty generally known that, in the construction of the Boston Metropolitan pipe system, the main lines of which consist of 48-in. pipes, few 48-in. gates were used, practically all the valves being 36-in., and this is considered good practice. The paper that Mr. Lally has given us is of the greatest assistance in forming judgment as to how far the principle, which has been more or less accepted for large pipes, is applicable to smaller ones.

* Consulting Engineer, Boston, Mass.

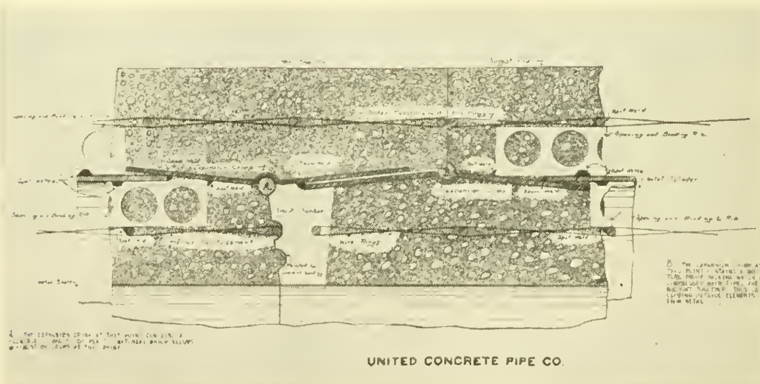
† Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

A NEW REINFORCED CONCRETE PIPE.

GEORGE C. BARTRAM.*

[*Read September 9, 1920*]

One of the most important questions that comes up for consideration by the members of this Association is the possibility of securing an ideal pipe line. The various qualities of an ideal line are, of course, dependent on the purposes for which and the conditions under which it is to be used. Under all conditions and for all purposes the pipe line must have the strength necessary to carry the pressure required, and should be leakproof, delivering at the outlet all of the water taken in at the inlet, and should have as low a coefficient of friction as possible. The line should not be subject to structural deterioration, nor should its carrying capacity decrease with age.



SECTION OF WALL OF PIPE

A. (Lower left-hand corner.) The expansion crimp at this point contains a flexible, fibrous, or plastic material which allows movement of crimp at this point.

B. (Lower right-hand corner.) The expansion crimp at this point contains a moisture-proof packing which is compressed when pipes are brought together, thus excluding outside elements from metal.

The defects and the merits in all of the systems now in use are well known. I propose to present to you the results of a series of extended investigations and experiments to develop a pipe line, especially for high-pressures, that will come as near to the ideal as seems possible. In my investigation I have kept in view the following points:

First, the method of construction must produce a line of sufficient strength to stand any pressure that may be required.

* President, United Concrete Pipe Company.

Second, the line must also be designed to the least amount of resistance to flow, and be so constructed as to maintain this low resistance.

Third, the line must have the minimum loss through leakage. The ideal line, you will readily understand, will show no leakage.

Fourth, length of life and maintenance cost.

Fifth, initial cost.

Naturally the first consideration is the material of which the line is to be constructed. From this point of view concrete is the only material which over centuries has shown the required unquestionable durability. It has also been proved by actual tests on constructed work that the coefficient of friction in a properly constructed concrete line is less than in any other form.

The question, therefore, arises, Is it possible to construct a line, based on the use of concrete as the principal material, which shall meet all of the other requirements set forth for an ideal line for both high and low pressure? How must the concrete line be given the necessary strength, and if constructed in sections how are the several sections to be combined into a unit line with the least possible obstruction to the flow of the water and the least leakage?

Taking the above points into consideration and looking over the field of what had been accomplished, we realized that the type of construction used on a great many miles of pipe line throughout New England, namely, the sheet-metal tube encased in concrete had proved its worth, and if this type of construction could be developed and designed so as to be utilized in larger sizes and a proper joint be made between the pipe sections, this would come nearer fulfilling the above requirements than any other type of pipe line that has been constructed. With this information it was a question of how to best use the principle involved in this structure that had already proved its possibilities. There is no necessity for me to go into details in this type of structure, as it has been used for so many years, principally in New England; so I will proceed to tell you how we propose to use this principle.

The thin sheet metal embedded in the concrete in small-diameter pipes would not require any means for mechanically bonding this concrete to the inside and outside faces of the sheet metal, as the thickness of the concrete casing and the metal are great enough to properly support the strain in these small sizes. To utilize this idea in larger pipes it becomes necessary to, in some way, form a mechanical bond that will cause the internal and external shells and the enclosed metal sheet to work in unison. This we accomplish by constructing a pipe built as follows:

In order to have an impervious pipe section of sufficient strength, in our design we use the necessary reinforcement, first with an impervious sheet-metal cylinder of such thickness as may be determined, and such additional reinforcement as may be required in the form of wire mesh or bars. The metal cylinder is constructed of sheet metal electrically welded,

so as to form an imperforate pipe, to the inside and outside faces of which we weld longitudinal perforated strips of metal. These strips not only act in the capacity of locking the reinforcement to the sheet-metal pipe, but also act as spacers to keep this reinforcement in the proper place. To the ends of the imperforate cylinder we weld sheet-metal rings, so formed as to take care of any contraction and expansion that may occur after the line is completed. These two rings are built into the pipe extending beyond the body of the pipe on the outside of the spigot and inside of the bell. When laid they form a lap joint on a bevel. This joint is electrically welded either from the inside of the pipe or the outside, as conditions may require.

This reinforced cylinder is then placed in the mold and the concrete poured, completing a pipe section. After seasoning, the pipe is laid in the trench and the metal joints are electrically welded. After the welding the open spaces are filled with concrete.

When the line is completed we have a continuous unbroken pipe line with the necessary contraction and expansion elements therein. So long as the line maintains its integrity there can be no leaks, as there is a continuous impervious metal cylinder without joints from intake to outlet. As the metal cylinder is thoroughly embedded in concrete it is protected from the action of the elements, and the only portion of the line subject to elemental action is concrete.

We believe that a line constructed as set forth will come nearer filling the requirements of an ideal pipe line than any that has ever been either used or offered.

In the construction of a low-pressure line it will be unnecessary to use the imperforate cylinder for the entire length of the line. By using a metal joint for uniting the several concrete sections, a line can be constructed to comply with all low-pressure requirements at a considerably lower cost.

TRENCHING-MACHINE EXPERIENCES IN THE CITY OF WORCESTER.

GEORGE W. BATCHELDER.*

[*September 10, 1920.*]

At the annual convention of the New England Water Works Association in 1917, held in the city of Hartford, a paper was presented which told the story of the use of the trenching machine up to that time.

In order to fully cover the subject up to the present time it will be necessary to repeat some points in the original paper.

The machine is a Model O, purchased of the Austin Drainage Excavator Company in 1913, at a cost of $7 000 less 5 per cent.

It is operated by steam, and was selected in preference to the gasoline machine because of the belief that there would be less trouble in securing operators who could handle a steam machine.

It has buckets of 18 in., 24 in., 30 in., and 36 in. width, and in each case the cut made is 6 in. wider because the teeth project 3 in. on each side.

As stated in the previous paper, trenches can be cut much wider than the buckets by barring down the material on each side of and in advance of the buckets.

The ordinary depth to which the machine cuts for water pipe in Worcester is 5 ft. This, of course, can be made more or less, with a range from 0 to 12 ft.

Best results are not obtained at the extreme depth because the boom runs so nearly vertical that the buckets spill much of the material before it reaches the conveyor belt.

Cuts have been made for a 48-in. pipe line with excellent results.

The machine has developed no weakness though it has been used in very hard digging.

It has done all of the trenching practicable in Worcester streets, and has been rented to municipalities and contractors in Hartford, Conn.; Quincy, Mass.; Dartmouth, Mass.; and Auburn, Mass., where it is now in operation.

Given a straight run in localities free from obstructions the machine is at its best and has cut hundreds of feet of trench in a day.

For use in the installation of new water or sewer systems in any soil except rock, it will go ahead so fast that the problem is to keep the pipe laid within hailing distance.

Examples of its work are shown in these records.

* Water Commissioner, Worcester, Mass.

Hartford, Conn., 1917.

June 26, New Park Ave., 155 ft. long, 36 in. wide, 5 ft. deep, 5 hours.
June 27, New Park Ave., 200 ft. long, 36 in. wide, 5 ft. deep, 6 hours.
July 6, New Park Ave., 220 ft. long, 36 in. wide, 5 ft. deep, 7 hours.
July 19, New Park Ave., 320 ft. long, 36 in. wide, 5 ft. deep, 8 hours.
July 24, Quaker Lane, 408 ft. long, 24 in. wide, 5 ft. deep, 8 hours.

Auburn, Mass., 1920.

Aug. 18 — Very coarse gravel, 410 ft. long, 24 in. wide, 5 ft. deep, 8 hours.
Aug. 19 — Loam, hardpan, and gravel, 250 ft. long, 24 in. wide, 5 ft. deep, 5 hours.
Aug. 20 — Hardpan, clay, and sand, 380 ft. long, 24 in. wide, 5 ft. deep, 6½ hours.
Aug. 21 — Sand and fine gravel, 165 ft. long, 24 in. wide, 5 ft. deep, 3 hours.
Aug. 23 — Filled land, very rocky, 384 ft. long, 24 in. wide, 5 ft. deep, 6½ hours.
Aug. 24 — Coarse gravel and sand, 438 ft. long, 24 in. wide, 5 ft. deep, 8 hours.
Aug. 25 — Very rocky and wet, 445 ft. long, 24 in. wide, 5 ft. deep, 8½ hours.
Aug. 26 — Fine gravel and hardpan, 295 ft. long, 24 in. wide, 5 ft. deep, 5½ hours.
Aug. 27 — Gravel, clay, and hardpan, 472 ft. long, 24 in. wide, 5 ft. deep, 8 hours.
Aug. 28 — Filled land, rocky, 180 ft. long, 24 in. wide, 5 ft. deep, 3½ hours.

This total excavation amounts to 34 190 cu. yd.

The costs of this work are:

Operator	$88.00
Fireman	66.00
Freight	38.00
Coal	48.00
Oil, etc.	20.00
Repairs and depreciation	20.00
Ex. labor	50.00
Total	$330.00

Cost of excavation per cubic yard	9.65 cents
Cost of excavation per cubic yard, including rental price	17.2 cents
Cost of excavation per cubic yard, hand labor (estimated)	63 cents

In addition to the work done in Worcester the machine has brought in a revenue for rentals of $9 011.28, not including the job now going on at Auburn, Mass.

The total cost of replacements and repair parts since the machine was purchased has been $3 864.44.

The machine shows no unusual signs of wear, and is apparently good for many years of service.

Discussion.

Secretary Gifford. What are the rental rates?

Mr. George W. Batchelder. Twenty-five dollars per day.

Secretary Gifford. Did I understand that a machine costs $7 000 and you had returns of $9 000 on it?

Mr. Batchelder. Yes.

SECRETARY GIFFORD. Isn't it about time to send that machine around to the Massachusetts fellow-members?

MR. BATCHELDER. I think that is a fine thing to do. We encourage people to call on us when they have need and our machine is not busy, and make a reasonable price to them to keep the machine going and to help the sister towns of our state.

MR. A. E. MARTIN.* I have prepared no paper in connection with the use of a trenching machine, for, as I advised Mr. Sherman when he asked me to do so, we have had a machine for so short a time that we have no statistics to prepare a paper on.

On account of the high cost of labor and the difficulty of procuring it, also its inefficiency, which is the last but perhaps not the least of the troubles, for two or three years past the Springfield Water Department has been contemplating the purchase of a trenching machine, and it finally developed this year that, having a few miles of pipe to lay in the outskirts of the city, a machine was purchased. We did not purchase so large a machine as the city of Worcester had, as our distances in traveling across the city are long and our bridges are not of sufficient strength, perhaps, to carry the weight. The machine we purchased is a model 24 Parsons Excavator, which is listed to cut a trench 26 in. wide. We did not expect that we could lay any pipe larger than 20 in. diameter, but as a matter of fact we have found that it would not be troublesome to lay a 24-in. or possibly even a 30.

Springfield, as perhaps most of you are aware, has a soil that is very easily worked. We have very little rock and no hardpan of any consequence, mostly sand digging, and in many cases firm enough to stand without bracing the sides of the trench. Practically the first work we did was to lay a 16-in. main, and by breaking down the bank, as has been already mentioned, we had no difficulty in laying with this small machine the 16-in. mains, making an average from 300 to 500 ft. per day with a small gang of 8 men, — not including the foreman, of course. We also purchased a backfiller, which I need not enlarge upon at the present time. It does its work very nicely, although it requires puddling to make it most effective, and sometimes it is hard work to get the water to it in the trench. We also, soon after laying this 16-in. main, removed an old 16-in. water main, and used the machine for doing it. We had about 2 700 ft. from one of our old ponds that was used to reinforce our Ludlow supply before we had our new system, and, as that main was earning us nothing and being of no value where it lay, we concluded to dig it up. With this gang of 8 men — which we finally succeeded in increasing to 12 (after we had raised wages to 67½ cents an hour) — we removed that 2 700 ft. in 20 actual working days. From the time we started to move our machine, taking the men from the previous job, was just four weeks to a day. We excavated the trench to the top of the pipe, as close to it as we could, then with

* Superintendent, Water Works, Springfield, Mass.

two men working along side of the pipe shoveling the dirt into the buckets, we excavated deep enough to get a chain under the pipe, then lifted it with a derrick.

It may be interesting to know that we melted about one half a joint by a kerosene torch; the pipe was then worked out with a derrick. We salvaged the lead, and the cost of removing that pipe, roughly, and getting the amount of lead that we salvaged, was about a dollar a foot. I have no figures on the number of cubic yards of excavation that we did, but the trench on the top was about $5\frac{1}{2}$ or 6 ft. wide, and sloped at the bottom to 24 in., and an average of 6 ft. deep.

This one dollar per foot included distributing the pipe where we proposed to re-lay it, about half a mile distant, so that the pipe itself distributed on the new job stands the department at the rate of about a dollar per foot, which, as you know, is quite cheap for a 16-in. pipe at the present time.

Our last job which we finished up before I came here was the lowering of a 30-in. main. We started by working the machine on one side of the pipe far enough away so that it would not hit the bells, then breaking down the bank on the other side with bars, and throwing it into the buckets by hand.

Six men were employed in the trench with the machine. About 400 ft. of 30-in. main was lowered and backfilled in about four days. We left bars under each length of pipe and dug out the dirt between them, and those bars were removed by a man on each side of the pipe with a shovel, the pipe lowering itself without trouble or without a hitch. Fifteen inches was the most that we lowered it at any one place, grading from either end.

We are now laying an 8-in. pipe, and if it is interesting to any of you, and it should be pleasant to-morrow, and you care to see its operation, we should be very glad to have you come down to Springfield, and we will show you the machine at work. As we are working now; we are not breaking the sides down, the bank being firm enough to stand, and yesterday afternoon, after making the connection with the new pipe that this is lateral from, they excavated for and laid about 250 ft. of pipe.

We know that we are doing more work and must be doing it cheaper. I will not make that assertion very strong, for we have no certificate to prove it, but we *are* doing *more* work, and we feel that it is going to be a successful and profitable investment.

Secretary Gifford. Mr. Martin, I should like you to state the cost of the machine in normal operation, the motive power, and the number of men to operate.

Mr. Martin. The machine is a gasoline machine, and it cost us, including some additions that we made to it, practically \$7 800. One of the additions that I referred to was that we were afraid to leave the machine on the street without some care over night. And we had to pay the

watchman laborer's pay and employ him seven days a week. So that an average of $35 a week or more was paid for the watchman. We went to one of our manufacturers in town and had a man come to see if a wire netting could be built around it, and he designed and finally built a wire cage similar to the grill work in banking institutions, and applied it to the machine. Since we have put that on we have not employed the watchman, and this cage, all on, cost us somewhere between $350 and $400, and we consider it a very good investment. The machine itself cost $7 200 plus the freight, which was somewhere around $150. One man can operate it, but we have hired an assistant for him, and pay the regular operator 80 cents an hour, and the assistant 70 cents.

SECRETARY GIFFORD. Perhaps I did not make myself clear, — I meant the number of men for pipe laying.

MR. MARTIN. We started with 8 men, and that gang was later increased to 12. The gang of 12 men will keep the machine at work, with the backfiller to help.

MR. DAVID A. HEFFERNAN.* From the time the order was placed, how long did you have to wait for the delivery of the machine?

MR. MARTIN. It was ordered in February and it was received the latter part of March. I should like to add that our machine stood on the tracks three weeks after it was loaded before it was moved. There was an embargo on the railroads, and we did not get the machine as quickly as we ought, but it was in time for our work.

MR. GEO. F. MERRILL.† We have a machine at Greenfield, the same as Springfield, Model 24 Parsons. We also have a backfiller. We had considerable delay in getting our machine. It was two months and a half *on the road* before delivery, and I had the pleasure of a trip to Chicago, spending about ten days on the road, hurrying it up, before we got delivery.

In regard to the use of the machine, I find that it is a great laborsaver. It sets a pace for the gang, and everything moves right along according to the pace of the machine. It really takes the "short" out of "shortage" of labor. It is very difficult to get men enough to handle pipe lines and dig any amount of trench. We have been using the machine in sand, which I imagine is much like Mr. Martin's conditions in Springfield. The day before yesterday, with our machine, we dug and laid 480 ft. of 8-in. wood pipe, and with a gang of 10 men, — two men directly behind the machine to keep the banks sloped down in the trench, so that we had a 6-ft. trench with $5\frac{1}{4}$ or 6 ft. width on top. It would average better than three quarters of a yard of material to the foot. One other day it laid 460 ft. under similar conditions.

I find we have to organize a gang of men particularly for use with the machine. We have got to look ahead and find out if there are any obstacles which are going to delay the machine. We have to keep the pipe-

* Superintendent Water Works, Milton, Mass.
† Superintendent Water Works, Greenfield, Mass.

laying material well ahead, and there is no doubt but that it is a very great labor saver. We also have used this machine on stiff clay and soft clay. On very hard, stiff clay the machine dug 200 ft. in three hours. That was in material hard enough so that it required no bracing. It would stand without sloping back. In soft clay we found the machine would not mire on very soft ground. The caterpillar treads with which machine is equipped give bearing enough so that it would go anywhere that an ordinary load on a wagon could travel. The backfiller goes with the machine and requires one man to operate it and will fill about twice as much trench as the machine will excavate in a day. Of course it requires puddling or some method of getting the filling into place. It wouldn't be very suitable to use on a street where it was paved, except by use of considerable labor in tamping or puddling the trench.

I haven't run into any very coarse gravel yet. I have not found any material that the machine would not go through. Roots are no obstacle. It will cut off roots as big as your leg and go right along. I imagine that round bowlders, close together, would delay a machine considerably. If you can loosen them up, the machine will handle them, if they are not too large; but it might not in an instance of that kind be profitable. Any material that we have struck we get away with it in good shape.

Mr. William R. Conard.* The experience we have had with trenching machines was during the war construction period. At Camp Dix there were five machines used. One Austin, one Parsons, and three Buckeyes. These machines were used alternately for the water-works construction and for the sewerage construction. I have no figures or knowledge of the amount of work done for the sewerage, but for the water works from August 10, when the work first started, until about the middle of October, we used on an average two machines. We were able to dig trench for laying about 85 000 ft. of 8- to 16-in. pipe. The best record made for the pipe laying was in laying the force main of 16-in. pipe, in which in one day of ten hours we excavated a trench of a little better than 1 200 ft. The average for the force main was about 800 ft. per day. The soil was, generally speaking, a sandy loam, which, of course, made the digging easy. There were no detail cost figures kept by the engineering department, because there was no time — it was too much of a rush job.

Afterward, at the May's Landing ordnance plant of the Bethlehem Loading Company, which I had under charge, we used a new Austin machine, and our average there was about 600 ft. of trench, the reason being that it was practically all sand, and about 90 per cent. wet work, so that we could not proceed as fast; and also the fact that in most places we had to have a stumping gang ahead of the machine to take out stumps. Considering the conditions at May's Landing, I think that the average shows very well for a trenching machine.

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* Inspecting Engineer, Burlington, N. J.

Later, when I want to Pittsburg for the Neville Island housing project, we were planning to use trenching machines, and were investigating, until the time of stopping work, on the various types of machines, the number to be used, and the probable cost. The soil at the site of the project, with the possible exception of eighteen to twenty inches of top soil, was of Pittsburg shale, and in our investigations of the various machines we figured that for part of the work we could use machines of the Austin or Parsons type, that we could not use the Buckeye type of machine, but that we could use to considerable advantage, for the shale, the Keystone machine, which can be made a combination of either excavator or trenching machine. The estimates of cost that were worked out at that time for a 5-ft. trench, as I recall them, ran about 65 cents per linear foot of excavation. That would have been for a 2-ft. trench, and the figures were compiled taking into consideration the type of excavating that it would be necessary to do. Of course, if there were considerable work, we should not have been able to excavate the full 5 ft., but should have been compelled to do considerable drilling and blasting after having gotten down a ways, and then go back and take out the material with the trenching machine, the nature of the soil making it possible to go back over the trench with a machine, which ordinarily would be impossible.

COÖPERATION IN USE OF EQUIPMENT.

Topical Discussion.

President Macksey. You will find on that program that you have charged me up to deliver an address which will not be inflicted upon you. Mr. Batchelder's paper and discussion thereof will give us a line as to where and how we may search for information relative to exchange of equipment.

Is it wise for small communities to buy expensive equipment, and saddle themselves with the expense of expert operators for same?

If we can find out how many cities and towns have shovels, trenchers, and other expensive equipment, and who are willing to rent them, and the prices at which they will rent, we can save money for our employers. I shall be glad to hear from any city or town that has such equipment and is willing to consider renting when it is not in use.

Mr. Wm. R. Conard.* Apropos of what Mr. Macksey says, the New England Water Works Association is for the use of the members of the Association, and therefore members should make the headquarters of the Association a clearing-house for just such matters as that. The members can indicate to the office what equipment they have, and record can be kept, and, if another member wishes to use some equipment, he can find out from the Secretary's office what equipment is available in stock and, by means of correspondence, whether it is available or not.

Vice-President Sherman. I should think that suggestion would be quite workable, and that the Executive Committee will probably arrange for a card index if members will notify what they have, if they are willing to lend. It would probably require some kind of a notification to the membership that such an information bureau was contemplated.

President Macksey. I move that the Executive Committee be requested to prepare a circular asking for information in relation to equipment used by cities and towns, and which is rentable, and that a circular asking for that information be sent out with a regular notice of the meetings.

Mr. Samuel H. Mackenzie.† I will second that motion, for I think it would be very beneficial, and I should like to benefit by it; and if the Executive Committee would take that up we should save quite a little time and expense.

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* Inspecting Engineer, Burlington, N. J.

† Engineer and Superintendent, Southington Water Works.

THE HOLYOKE WATER WORKS, AND ITS RAINFALL AND STREAM-FLOW MEASUREMENTS.

BY P. J. LUCEY.

[*September 7, 1920.*]

The Municipal Water Works of Holyoke was first established in 1872, to provide for the growing needs of a town of about 10 000 inhabitants inadequately served by a private company.

Since then the town has grown to be a city of 62 000 population, noted for the excellence of its water-power development and for being the center of the paper industry in Massachusetts, and the leading city in the United States in the production of fine writing paper.

According to the federal census of 1910, it ranks twelfth in the list of Massachusetts cities in population and tenth in the valuation of its manufactured products.

It is distinctly a manufacturing city, having many large and prosperous textile plants whose output is more important, even in Holyoke, than that of its 27 paper mills.

One of the finest masonry dams in the world, superior in its materials and perfect in its workmanship, 1 020 ft. long and 30 ft. high above the bed rock, together with a well-arranged system of distribution canals, diverts the Connecticut River, whose drainage area is 8 000 square miles, to the useful purposes of industry with a wheel development of about 30 000 h.p.

Steam power, supplementing the hydraulic development, requires in the course of a year approximately 600 000 tons of coal, and the total railroad freight tonnage of its raw and manufactured products exceeds that of any other city in New England, except Boston and Worcester.

The area included within its boundaries is about 23 square miles; the greatest extent easterly and westerly being about 5 miles, and northerly and southerly about $9\frac{1}{4}$ miles. The built-up portion of the city covers about one third of its whole area, the remainder being mountain-land and small farms.

The water supply of Holyoke is obtained from the mountain streams in the western part of the city, whose drainage areas are fully developed by storage reservoirs high enough above the city to provide satisfactory pressure by gravity, and an auxiliary supply, the head waters of the Manhan River in Southampton, at a still higher elevation, which is connected with the local reservoirs by a 20-in. cast-iron main. These local reservoirs

Engineer for Water Department, Holyoke, Mass.

are known as the Ashley, Whiting Street, and the High Service reservoirs, and their construction and development was in the period between the years 1872–1904.

The Ashley System.

The Ashley Reservoir is located in the southwesterly part of the city, about $3\frac{1}{2}$ miles from the City Hall, and consists of two natural lakes, which were the first of the reservoirs to be developed and used in 1872, the overflow having been raised about 5 ft. since then. It also includes the Bray Reservoir, built in 1880 to provide a small additional storage.

The drainage area of the Ashley system, not including its water surface, is 2.58 square miles. The surface area is 286 acres, and the elevation of its spillway is 322 ft. above sea level, about 170 ft. higher than the principal business street. The available storage capacity above the intake pipe is 854 million gallons, with an additional storage below it of 660 million gallons, which is available by pumping. The development per square mile of drainage area without recourse to pumps is 282 million gallons.

Fifty-two per cent. of the land inside the watershed boundaries is owned by the department, and there are only two dwelling-houses with a population of three to the square mile.

Whiting Street System.

The Whiting Street system consists of two reservoirs in the northwestern part of the city, at the easterly foot of Mt. Tom.

The first reservoir was a small intake built in 1884, with a low masonry dam flooding about an acre, with a capacity of about $1\frac{1}{2}$ million gallons. The elevation of the spillway is 358 ft.

The other reservoir is the storage reservoir built in 1888, with a masonry dam of rubble sandstone 1 773 ft. long, the maximum height being about 25 ft. The surface area of this reservoir is 114 acres; the elevation of the spillway is 390 ft.; and the capacity is 479 million gallons, all of which is available. The drainage area is 1.47 square miles, and the development is 326 million gallons to the square mile.

There are no dwellings on this drainage area, about one third of which is owned by the Water Department.

The Manhan System.

The Manhan source of supply was secured in 1896, when, owing to the growth of the city, the consumption of water exceeded the safe combined capacity of Ashley and Whiting Street systems.

The development of this source as proposed at the beginning of the work was to construct a small intake reservoir at the junction of the Manhan and Tucker brooks in Southampton, Mass., where the drainage area

is 13.02 square miles, and connect it with the Ashley Reservoir by a 20-in. cast-iron main. This development was to serve until such time as a storage reservoir would be required, which was estimated then to be about fourteen years.

Accordingly, in 1896 and 1897, what is called the Fomer Reservoir was constructed by building a gravel dam with a concrete core at the junction of these brooks, having a length of 900 ft. and a maximum height of 20 ft.

The surface area of this reservoir is about 10 acres, and its capacity is 17 million gallons. The spillway at the westerly end of the dam is 150 ft. long between concrete wing walls, and the elevation of its crest is 440 ft. and is 5 ft. below the top of the dam.

Fomer Pipe Line.

In 1897 and 1898 a 20-in. cast-iron pipe 56 112 ft. in length was laid, connecting this reservoir with the Ashley Reservoir, where it terminated in a masonry canal in which was built a weir 4 ft. in length, for the purpose of measuring the discharge.

The first measurements, taken in 1898, showed the discharging capacity of this main to be at the rate of 4 572 000 gal. per day. Since then the discharge is constantly growing less, it now being 3 728 000 gal. per day, a loss of about 18 per cent. in twenty-two years. In 1918 a pitometer measurement of the discharge gave the rate as 3 840 000 gal. per day, checking the weir measurement made at the same time within four tenths of one per cent.

High-Service Reservoir.

To provide for the residential section developing on the higher area of the city, an earth dam, with a concrete core, was built on the Ashley drainage area, forming the High-Service Reservoir, and the pipe line from the Fomer Reservoir to the Ashley Reservoir was extended to it.

As the drainage area of this reservoir is only 47/100 of a square mile the greater part of the water drawn from it comes from the Manhan source, for which it acts as a holding and distributing reservoir.

The length of this dam is approximately 500 ft., and its average height is 25 ft.

On the southerly side of the reservoir is a dike about 900 ft. long, whose maximum height is 15 ft.

This dike served as a spoil bank for the stripping from the reservoir basin, which was very thoroughly done, and in some places this dike is over 100 ft. wide. It was thought best, however, to build it with a core wall and to construct that part of the embankment on the water side of the core wall with selected material.

The surface area of this reservoir is 61 acres, and its capacity, all of which is available, is 354 million gallons.

The elevation of the spillway is 431.50 ft., and all the water passing over it discharges into the Ashley Reservoir.

There are no dwellings on this drainage area, — 53 per cent. of which is owned by the Water Department.

Construction work on this reservoir was begun in 1899 and completed in 1904, all the work being done by the department's own forces, at a cost of about \$135 000, of which about \$85 000 was provided from the yearly earnings of the department and the balance by a bond issue for ten years.

Although the difference in elevation between the spillway of this reservoir and the spillway of the Fomer Reservoir is only $8\frac{1}{2}$ ft., and the long pipe line would give a comparatively small discharge, it was expected that it would be sufficient until the projected storage reservoir on the Manhan would be built, when the main could be extended up the Manhan Brook to a small intake whose elevation would be high enough above the High-Service Reservoir to discharge the required quantity into it.

The White Reservoir.

The White Reservoir is situated on the Manhan Brook, about two miles upstream from the Fomer Reservoir, and was constructed in 1911–12, to provide the storage necessary to keep the 20-in. pipe filled when the run-off of the streams was no longer sufficient to supply the requirements of the Ashley and High-Service reservoirs.

A concrete dam was designed by and built under the supervision of the city engineer, T. J. MacCarthy.

It is 360 ft. long with a maximum height of 48 ft. and holds 650 million gallons when filled to the elevation of its spillway, which is 715 ft.,—275 ft. higher than the Fomer Reservoir to which the water is allowed to flow as required. Its surface area is 132 acres, and its drainage area, exclusive of water surfaces, is 3.8 square miles. The total cost of dam and reservoir was \$150 000, for which serial bonds running for thirty years at four per cent. were issued.

The New Intake Dam.

The dry seasons, locally, of 1913 and 1914 demonstrated the fact that the time had arrived to increase the discharge of the Manhan water into the High-Service Reservoir, the draft from which had more than doubled since it was first put in operation.

Consequently, in 1915 a 20-in. cast-iron main was laid up the Manhan Brook to the site of a proposed intake reservoir.

A concrete dam 12 ft. high and 147 ft. long, including a spillway of 80 ft., was finished in 1917, at a cost of about \$18 000, the work being done by the department's own forces.

Summary of Sources of Supply.

A summary of the sources of supply shows that the total drainage area of land surfaces contributing to the reservoirs is 17.52 square miles; the area of the water surfaces of all the reservoirs is 93/100 of a square mile, and the total storage capacity is 2 354 million gallons. The safe capacity of the present developments is estimated to be sufficient for a city of 70 000, on the basis of present consumption, and when the Manhan drainage area is fully developed it is estimated that the sources of supply will provide for a city of about 110 000 population.

Distribution.

The distribution system is divided into the Low- and the High-Service districts, so-called not on account of the difference in pressures but to represent the lower and higher areas in the city which they serve.

The Low-Service District includes practically all the manufacturing and commercial users of water and has a residential population of 48 265, while the High-Service is entirely a residential district in the western part of the city and has a population of 13 425.

The Low-Service District is supplied by the Ashley Reservoir and the Whiting Street Reservoir; the High-Service District usually by the High-Service Reservoir alone, although occasionally a part of this district is supplied by the Whiting Street Reservoir.

Supply Mains.

The supply mains from Ashley Reservoir are a 24-in. cast-iron main, about 17 000 ft. long, laid from the gatehouse at the northeasterly corner of the reservoir to the center of the principal mercantile district, and a 16-in. main laid directly beside it for about 8 000 ft., where it is cross-connected with the 24-in. cast-iron main. There is also a 12-in. main taken off the 24-in. about 600 ft. from the reservoir, connecting with the distribution system at the extreme southerly part of the city.

The supply main from the Whiting Street Reservoir to the low-service distribution system is about 14 000 ft. long. It is a compound pipe of 20-in., 16-in., and 12-in. diameters, having a carrying capacity a little better than that of a 14-in. main.

The supply main from the High-Service Reservoir to the High-Service District is about 15 000 ft. long and is 20 in. in diameter for about 7 000 ft. from the reservoir, reducing to 16 in. for the remaining 8 000 ft. The capacity of all the supply mains is about 22 million gallons per day.

The mains inside the distribution system are all cast iron and total about 75 miles ranging from 4 in. to 24 in. in diameter.

The secondary feeders are 10 in., 12 in., and 16 in., and the distributors are generally 6 in. and 8 in.

The 4-in. mains are in many cases paralleled by mains of larger size and do not directly supply hydrants.

The percentage of the various sizes of pipes in the distribution system are as follows: 4-in., 10 per cent.; 6-in., 38 per cent.; 8-in., 18 per cent.; the 10-in., 12 per cent.; 12-in., 12 per cent.; 16-in., 7 per cent.; and 24-in., 3 per cent.

Pressures.

The pressure in the Low-Service District varies from 25 lb. minimum to 105 lb. maximum, the average being 77 lb.

In the principal business part of the city the range is from 64 lb. to 80 lb.; and in the High-Service District from 66 lb. to 111 lb., the average being 81 lb.

The average pressure for the whole of the city is taken as 79 lb.

Hydrants.

There are 779 hydrants in public use, and 282 private hydrants in mill yards which are connected with and supplied from the city mains.

There are also 52 fire pumps in the mills which pump water from the canals, and the connections between these pumps and the water department's mains are all equipped with check valves and stop gates.

In the matter of fire protection Holyoke ranks well with the underwriters, being one of the few cities in New England which enjoys the lowest rates for insurance, and the water department is graded by the National Board of Underwriters as a city of the first class, having a total deficiency of only one hundred and forty-five points out of a possible seventeen hundred.

Consumption.

The consumption is measured by two Venturi and two Premier meters on the main feeders from the reservoirs.

The average daily consumption for 1919 was 6 664 000 gal., or 108 gal. per day per capita.

The consumption for the largest day was at the rate of 135 gal. per day per capita, and for the lowest day it was 86 gal. per day per capita.

The average daily consumption per capita for the largest week was 122 gallons, and for the smallest week it was 99 gal.

The classification and quantity of water used in gallons per day was as follows, viz.:

Domestic, metered	3.3 gal.
Public, metered (schools, engine houses, etc.)	3.7 gal.
Commercial, metered	10.0 gal.
Manufactured, metered	[illegible].0 gal.
Total metered water sold	[illegible]6.0 gal.
Water sold by fixture rate and unaccounted for	72.0 gal.
Totals	108.00 gal.

Service Pipes.

The service pipes are installed by the department at the expense of the consumer. The department makes the tap and lays the pipe to the inside of the cellar. Since the early part of the present year the rule of the department is that for taps on mains laid before 1918 a charge is made for stock and time plus a fixed sum from $10.00 upward, according to the size of the tap; and for taps on mains laid since 1918 a charge of $1.00 per front-foot of premises is made in addition to the charge for stock and time.

None but department employees are allowed to make taps, lay service pipes, or operate curb cocks.

Nearly every variety of service pipe is in use in Holyoke, but services less than 2 in. are mainly either lead lined or galvanized, while services over 2 in. are all cast iron.

The total number of services is 4 871, of which 10 per cent. are metered.

Rainfall and Run-Off on Manhan Drainage Area.

When the Manhan drainage area was taken as a source of water supply there was, of course, no records of its rainfall and run-off, and the computations of its probable yield were based on the flow of streams in other localities, particularly that of the Sudbury River.

In the summer of 1896 weirs were built on both the Manhan and Tucker brooks, just above the flowage line of the proposed new intake reservoir, and a rainfall station was established at a point just below the site of the proposed dam.

The weirs were of the standard rectangular type, with sharp crests and end contractions built so there would be no velocity of approach at time of ordinary flow.

Measurements were made twice daily, and more frequently in rainy weather, with a hook gage on both of these weirs, until the construction of the White Dam on the Manhan Brook in 1912. Since then no computations of the flow of this brook have been made.

Stream flow in the records reduced to a square-mile basis are for the combined flow of the two streams from 1897 to 1910 inclusive, and for the Tucker Brook alone since then.

The records of rainfall and stream flow for the dry years 1899 and 1908–09–10–11 were given in the report of the committee on yields of watersheds, and some of the information given there is repeated at this time.

The drainage area of the Manhan stream was 7.25 square miles, and was measured by a weir 10 ft. in length; the drainage area of the Tucker Brook is 5.75 square miles and the weir is a permanent concrete one whose crest is 6 ft. in length.

The drainage areas of both streams are similar in character, being rather mountainous with steep slopes. The soil is generally gravelly, and

about three quarters of the total area is wooded. There are no water surfaces except about a couple of hundred acres of undrained swamps.

The elevation ranges from 440 at its lower end to 1 550 at its upper end, about 6 miles northerly; the average elevation being about 950 ft.

Only about 3 per cent. of the land is under cultivation, the policy of the water department in buying land for the sanitary protection of the water having reduced the number of farms and inhabitants so that the population now is only about five to the square mile, and the real estate holdings of the department are about 25 per cent. of the total area.

Rainfall.

The rainfall is measured with a standard United States Weather Bureau gage, 8 in. in diameter, whose top is about 12 in. above the ground, and the measurements have all been made by the same observer.

The rainfall that has been received at this station from 1897 to 1919, both inclusive, is recorded in the following series of tables, and a comparison is made with that received on the Nashua River drainage area whose records cover exactly the same period of time and are widely known and accepted as standard.

The mean annual rainfall for the period of twenty-three years is 47.91 in., which is about 6 7/10 per cent. greater than the mean of the Nashua for the same period.

The maximum year was 59.41 in. in 1897, which is 24 per cent. greater than the mean; and the minimum year was 38.29 in. in 1899, 20 per cent. less than the mean.

The highest average for two successive years is 23 per cent. greater than the mean, and the lowest average of two successive years is 16 per cent. less than the mean.

The highest average for three successive years is 18 per cent. greater than the mean, and the lowest average of three successive years, 1917, 1918, and 1919, the last years of the period, is 12 per cent. less than the mean.

The greatest variation found in any one year between the annual rainfall on the Manhan and Nashua areas was in 1910, a year of low rainfall generally throughout Massachusetts, when the rainfall on the Manhan was 23 per cent. greater than that on the Nashua.

It also exceeded the amount received at Amherst by 29 per cent.; the amount at the Springfield Water Works station at Little River by 32 per cent.; and at our High-Service Station by 27 per cent., illustrating the well-established fact that rainfall may differ widely at stations not very far apart.

The rainfall received at the Granville station of the Westfield Water Works about 15 miles southerly, was only 10 per cent. less than the Manhan, and the high rainfall for the year was evidently local to those two areas.

It might be interesting at this point to state that although there were twelve of the twenty-three years when more rainfall was received on the Manhan, there were only ten years when the run-off was greater.

The variation in the annual rainfall from the minimum to the maximum is about the same on the Manhan as on the Nashua, the difference on the Manhan being 21.12 in., and on the Nashua 20.07 in.

The records show that the mean rainfall is quite evenly distributed throughout the year, and that the spring months although more favorable for the collection of surplus water are not the months of greatest rainfall.

The three consecutive months of highest rainfall are July, August, and September, and the amount received in the last six months of the year exceeds that in the first six.

November, which averages the month of lowest rainfall, with 3.32 in., is the second lowest month on the Nashua, with an average of 3.39 in.

In the series of twenty-three years, there were three years when November was the lowest month in the year, but there was no year when November was the wettest or next to the wettest month in the year.

The least rainfall received in any November was 1.00 in., but there are five years when the rainfall of other months was lower than that.

The wettest November was 6.59 in. in 1907, which amount was exceeded in some year by every one of the other months at least once, and by some of the months several times.

August averages the wettest month in the series, with 4.58 in., and is likewise the wettest month in the Nashua records, with 4.14 in.

On the Manhan it is found to be the wettest month in only one of the twenty-three years, but in no year in the series was it the month of lowest rainfall, and it ranked generally among the wettest months.

October presents more extremes than any other month, being the wettest month in four and the driest month in five of the twenty-three years.

The maximum rainfall received in any one month was 14.33 in. in June, 1903, and the minimum was .15 in. in March, 1915, a month notable all over Massachusetts for its deficiency in rainfall.

The average number of days in a year when the rainfall received was greater than .01 of an inch is one hundred and seven. The maximum number was one hundred twenty-one in 1916, and the minimum eighty-five in 1899.

The number of days when the rainfall was 1 in. or more ranged from twenty in 1901 to seven in the years 1911–1917, 1918.

The greatest number of days in a year when the rainfall was 2 in. or more was six; 3 in. or more, two; and 4 in. or more, one. There was no rainfall for twenty-four hours which equaled 5 in.

The maximum rainfall in any one day was 4.35 in.

The maximum rainfall for one day in the years 1899 and 1913, both years of low rainfall, was 1.75 in.

The greatest number of consecutive days without rain ranged from nine in 1907 to thirty-three in 1912.

TABLE 1.

MONTHLY RAINFALL IN INCHES RECEIVED ON MANHAN DRAINAGE AREA OF THE HOLYOKE WATER WORKS FOR TWENTY-THREE YEARS, 1897–1919 INCLUSIVE.

	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
January	4.29	5.765	3.045	3.59	2.11	3.32	1.88	3.60	4.75	2.64	2.92	3.41
February	2.89	4.47	3.36	10.28	0.78	4.66	5.30	2.61	1.72	2.43	1.62	4.84
March	3.27	2.49	6.87	5.54	6.29	6.38	5.57	4.43	3.69	4.45	1.96	3.44
April	2.41	4.195	1.92	1.885	10.98	4.45	3.63	6.87	2.70	5.37	2.49	3.19
May	4.05	6.16	1.31	4.44	9.87	2.08	0.89	4.22	0.99	5.45	3.77	7.19
June	7.16	4.165	2.43	1.78	1.96	2.85	14.33	6.65	2.99	3.34	4.54	1.70
July	13.96	3.955	5.075	2.49	2.59	5.75	3.80	3.01	5.96	6.51	2.85	4.40
August	6.32	7.275	1.94	3.91	6.15	4.63	7.815	5.07	5.54	2.59	1.73	4.10
September	1.235	3.35	5.01	2.11	4.76	5.34	2.385	4.73	8.89	2.99	11.58	1.85
October	1.25	7.405	1.31	3.42	4.77	6.99	3.915	3.56	2.94	2.80	6.70	2.62
November	6.01	5.92	3.16	4.31	1.54	1.62	1.70	1.00	1.86	3.01	6.59	1.02
December	6.57	3.73	2.86	3.27	4.79	7.46	6.28	2.96	4.16	3.66	4.91	2.91
Total	59.415	58.88	38.29	47.025	56.59	55.53	57.495	48.71	46.19	45.24	51.66	40.67

	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	Mean.
January	4.33	7.97	2.08	3.65	3.61	3.21	6.605	1.81	4.57	3.81	2.30	3.71
February	6.41	6.88	1.905	3.12	2.32	5.65	5.575	6.44	2.36	1.85	3.25	3.91
March	5.295	1.60	1.195	5.39	5.78	4.32	0.15	2.83	4.19	1.58	6.13	4.17
April	6.45	5.36	2.62	3.26	3.95	5.13	3.97	4.44	2.24	2.90	2.54	4.04
May	1.00	3.58	0.84	4.60	5.19	1.005	2.27	3.24	3.40	2.86	8.38	4.03
June	3.12	3.70	4.06	0.80	0.67	2.01	2.43	5.89	5.23	4.30	1.75	3.82
July	1.46	1.67	4.43	2.43	1.88	3.18	8.96	5.42	1.84	2.88	4.66	4.30
August	4.70	1.48	6.71	4.96	2.37	3.20	9.82	2.06	3.07	3.84	3.00	4.58
September	4.36	3.07	1.55	3.375	3.44	0.185	2.08	8.04	0.72	6.67	1.02	4.12
October	1.32	0.72	8.84	5.79	6.77	2.03	2.01	1.55	9.37	1.43	2.56	3.92
November	2.34	5.59	2.58	4.24	3.74	3.32	3.41	3.79	1.03	2.93	5.75	3.32
December	3.64	1.87	2.98	4.70	3.06	3.14	5.42	2.97	4.30	3.47	2.06	3.96
Total	47.125	46.49	45.79	46.315	42.78	39.38	52.70	48.48	42.32	38.52	46.40	47.91

Average yearly rainfall, 47.91 in.
Maximum yearly rainfall, 59.415 in. in 1897, — 24 per cent. greater than the average.
Minimum yearly rainfall, 38.29 in. in 1899, — 20 per cent. less than the average.
Maximum average of two successive years, 59.15 in., 1897–1898, 23 per cent. greater than the average.
Minimum average of two successive years, 40.42 in., 1917–1918, — 16 per cent. less than the average.
Maximum average of three successive years, 56.54 in., 1901–1902–1903, — 18 per cent. greater than the average.
Minimum average of three successive years, 42.41 in., 1917–1918–1919, — 11 per cent. less than the average.

TABLE 2.

MONTHLY RAINFALL RECEIVED ON MANHAN DRAINAGE AREA, 1897–1919 INCLUSIVE. MONTHS IN ORDER OF DRYNESS.

Order of Dryness.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
1........	1.235	2.49	1.31	1.78	0.78	1.62	0.89	1.00	0.99	2.43	1.62	1.02
2........	1.25	3.35	1.31	1.885	1.54	2.08	1.70	2.61	1.72	2.59	1.73	1.70
3........	2.41	3.73	1.92	2.11	1.96	2.85	1.88	2.96	1.86	2.64	1.96	1.85
4........	2.89	3.955	1.94	2.49	2.11	3.32	2.385	3.01	2.70	2.80	2.49	2.62
5........	3.27	4.165	2.43	3.27	2.59	4.45	3.63	3.56	2.94	2.99	2.85	2.91
6........	4.05	4.195	2.86	3.42	4.76	4.63	3.80	3.60	2.99	3.01	2.92	3.19
7........	4.29	4.47	3.045	3.59	4.77	4.66	3.915	4.22	3.69	3.34	3.77	3.41
8........	6.01	5.765	3.16	3.91	4.79	5.34	5.30	4.43	4.16	3.66	4.54	3.44
9........	6.32	5.92	3.36	4.31	6.15	5.75	5.57	4.73	4.75	4.45	4.91	4.10
10........	6.57	6.16	5.01	4.44	6.29	6.38	6.28	5.07	5.54	5.37	6.59	4.40
11........	7.16	7.275	5.075	5.54	9.87	6.99	7.815	6.65	5.96	5.45	6.70	4.84
12........	13.96	7.405	6.87	10.28	10.98	7.46	14.33	6.87	8.89	6.51	11.58	7.19
Total......	59.415	58.88	38.29	47.025	56.59	55.53	57.495	48.71	46.19	45.24	51.66	40.67

Order of Dryness.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	Total.	Average.
1.......	1.16	0.72	0.84	0.80	0.67	0.185	0.15	1.55	0.72	1.43	1.75	27.155	1.18
2.......	1.32	1.60	1.905	2.43	1.88	2.01	2.01	1.81	1.03	1.58	2.06	43.085	1.87
3.......	2.34	1.67	2.08	3.12	2.32	2.03	2.08	2.06	1.84	1.85	2.30	51.82	2.25
4.......	3.12	1.87	2.58	3.26	2.37	3.14	2.27	2.83	2.24	2.86	2.54	61.79	2.69
5.......	3.64	3.07	2.62	3.375	3.06	3.18	2.43	2.97	2.36	2.88	2.56	71.20	3.10
6.......	4.00	3.58	2.98	3.65	3.44	3.20	3.41	3.24	3.07	2.90	3.00	79.895	3.47
7.......	4.33	3.70	4.06	4.24	3.61	3.21	3.97	3.79	3.40	2.93	3.25	87.66	3.81
8.......	4.36	4.48	4.195	4.60	3.74	3.32	5.42	4.44	4.19	3.47	4.02	100.74	4.38
9.......	4.70	5.36	4.43	4.70	3.95	4.005	5.575	5.42	4.30	3.81	4.66	111.23	4.83
10.......	5.295	5.59	4.55	4.96	5.19	4.32	6.605	5.89	4.57	3.84	5.75	124.66	5.42
11.......	6.41	6.88	6.71	5.39	5.78	5.13	8.96	6.44	5.23	4.30	6.13	146.685	6.38
12.......	6.45	7.97	8.84	5.79	6.77	5.65	9.82	8.04	9.37	6.67	8.38	196.075	8.53
Totla....	47.125	46.49	45.79	46.315	42.78	39.38	52.70	48.48	42.32	38.52	46.40	1 101.995	47.91

Average monthly for twenty-three years, 3.99 in.
Average of 1st driest month, 1.18 in., — 70 per cent. less than mean.
Average of 12th driest month, 8.53 in., — 114 per cent. greater than mean.

TABLE 3.

MONTHLY RAINFALL RECEIVED ON MANHAN DRAINAGE AREA, 1897–1919. CALENDAR MONTHS IN ORDER OF DRYNESS.

Driest.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Average.
1.....	1.81	0.78	0.15	1.885	0.84	0.67	1.16	1.73	0.185	0.72	1.00	1.87	12.80	1.07
2.....	1.88	1.62	1.58	1.92	0.89	0.80	1.67	1.94	0.72	1.25	1.02	2.06	17.35	1.45
3.....	2.08	1.72	1.60	2.24	0.99	1.70	1.84	2.06	1.235	1.31	1.03	2.86	20.665	1.72
4.....	2.11	1.85	1.96	2.41	1.31	1.75	1.88	2.37	1.85	1.32	1.54	2.91	23.26	1.94
5.....	2.30	1.905	2.49	2.49	2.08	1.78	2.43	2.59	2.08	1.43	1.62	2.96	26.15	2.18
6.....	2.64	2.32	2.83	2.54	2.27	1.96	2.49	3.00	2.11	1.55	1.70	2.97	28.38	2.36
7.....	2.92	2.36	3.27	2.62	2.86	2.01	2.59	3.07	2.385	2.01	1.86	2.98	30.93	2.58
8.....	3.045	2.43	3.44	2.70	3.24	2.43	2.85	3.20	2.99	2.03	2.34	3.06	33.755	2.81
9.....	3.21	2.61	3.69	2.90	3.40	2.43	2.88	3.84	3.07	2.56	2.58	3.14	36.31	3.03
10.....	3.32	2.89	4.19	3.19	3.58	2.85	3.01	3.91	3.35	2.62	2.93	3.27	39.11	3.26
11.....	3.41	3.12	4.195	3.26	3.77	2.99	3.18	4.10	3.375	2.80	3.01	3.47	40.68	3.39
12.....	3.59	3.25	4.32	3.63	4.00	3.12	3.80	4.48	3.44	2.91	3.16	3.64	43.37	3.62
13.....	3.60	3.36	4.43	3.95	4.005	3.34	3.955	4.63	4.02	3.42	3.32	3.66	45.69	3.81
14.....	3.61	4.47	4.45	3.97	4.05	3.70	4.40	4.70	4.36	3.56	3.41	3.73	48.41	4.03
15.....	3.65	4.66	5.295	4.195	4.22	4.06	4.43	4.96	4.55	3.915	3.74	4.16	51.835	4.32
16.....	3.81	4.84	5.39	4.44	4.44	4.165	4.66	5.07	4.73	4.77	3.79	4.30	54.405	4.53
17.....	4.29	5.30	5.54	4.45	4.60	4.30	5.075	5.54	4.76	5.79	4.24	4.70	58.585	4.88
18.....	4.33	5.575	5.57	5.13	5.19	4.54	5.42	6.15	5.01	6.70	4.31	4.79	62.715	5.23
19.....	4.57	5.65	5.78	5.36	5.45	5.23	5.75	6.32	5.34	6.77	5.59	4.91	66.72	5.56
20.....	4.75	6.41	6.13	5.37	6.16	5.89	5.96	6.71	6.67	6.99	5.75	5.42	72.22	6.02
21.....	5.765	6.44	6.29	6.45	7.19	6.65	6.51	7.27	8.04	7.405	5.92	6.28	80.215	6.68
22.....	6.605	6.88	6.38	6.87	8.38	7.16	8.96	7.815	8.89	8.84	6.01	6.57	89.36	7.45
23.....	7.97	10.28	6.87	10.98	9.87	14.33	13.96	9.82	11.58	9.37	6.59	7.46	119.08	9.92
Total...	85.265	90.72	95.84	92.95	92.785	87.855	98.86	105.28	94.74	90.07	76.46	91.17	1 101.995	91.84
Average.	3.71	3.94	4.17	4.04	4.03	3.82	4.30	4.58	4.12	3.92	3.32	3.96	47.91	3.99

Mean monthly rainfall in twenty-three years, 3.99 in.
Rainfall for minimum month in twenty-three years, 0.15 in. in March, 1915.
Rainfall for maximum month in twenty-three years, 14.33 in. in June, 1903.
Average minimum calendar month is November, 3.32 in., — 17 per cent. less than mean average.
Average maximum calendar month is August, 4.58 in., — 15 per cent. greater than mean average.

TABLE 4.

DRIEST MEAN CONSECUTIVE MONTHS ON BASIS OF MANHAN RAINFALL, 1897–1919 INCLUSIVE.

Number of Consecutive Months.	Months.
1	November.
2	October and November.
3	September, October, November.
4	September—December, inclusive.
5	January—May, inclusive.
6	January—June, inclusive.
7	January—July, inclusive.
8	May—December, inclusive.
9	April—December, inclusive.
10	March—December, inclusive.
11	January—November, inclusive.
12	January—December, inclusive.

TABLE 5.

WETTEST MEAN CONSECUTIVE MONTHS ON BASIS OF MANHAN RAINFALL.

Number of Consecutive Months.	Months.
1	August.
2	July and August.
3	July, August, September.
4	July—October, inclusive.
5	April—August, inclusive.
6	March—August, inclusive.
7	February—August, inclusive.
8	February—September, inclusive.
9	February—October, inclusive.
10	January—October, inclusive.
11	February—December, inclusive.
12	January—December, inclusive.

RUN-OFF.

The yield of the Manhan drainage area given in the following tables is on the basis of one square mile of drainage area for the combined flow of the Manhan and Tucker brooks for the years 1897–1910, inclusive, and for one square mile of the Tucker Brook drainage area for the years 1911–19, inclusive.

For the fourteen years in which measurements were made on the two brooks, the total run-off of the Tucker exceeded that of the Manhan by 1 72/100 per cent.

TABLE 16.

YIELD OF MANHAN DRAINAGE AREA IN MILLION GALLONS PER SQUARE MILE PER MONTH, 1897–1919 INCLUSIVE.

	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
January	19.996	42.706	45.558	14.632	9.427	72.593	45.650	21.931	70.264	35.609	40.389	55.130
February	29.976	31.287	20.242	116.188	5.526	36.275	58.163	19.198	16.473	20.473	15.304	42.432
March	75.626	117.074	50.634	86.821	68.637	133.004	125.716	82.160	91.445	50.621	72.137	76.647
April	62.604	68.798	147.789	59.537	195.499	69.759	82.601	142.516	77.161	90.108	44.405	58.344
May	36.206	75.718	25.605	47.154	123.050	30.858	17.026	53.967	19.631	42.992	38.181	88.163
June	48.868	37.087	7.427	11.220	30.469	11.893	81.556	63.556	11.342	18.722	29.277	22.107
July	141.361	10.694	11.300	4.617	8.970	17.309	35.303	19.916	14.597	16.048	9.307	13.027
August	59.251	20.773	3.967	5.251	19.409	15.575	45.624	15.589	7.200	9.675	2.934	10.645
September	17.477	8.940	8.937	2.357	25.893	22.885	19.452	25.451	54.176	5.597	46.035	5.107
October	9.838	39.352	6.124	5.659	23.773	51.197	42.091	29.019	20.675	21.085	69.656	7.386
November	33.651	57.376	13.016	29.791	15.735	27.422	28.965	18.512	18.635	22.127	94.035	7.592
December	71.322	47.097	13.991	29.476	81.938	56.264	48.431	19.804	30.031	23.187	49.920	8.522
Total	606.176	556.902	354.590	412.703	608.326	545.034	630.578	511.619	431.630	356.244	511.580	395.102
Average daily	1.661	1.526	0.971	1.131	1.667	1.493	1.728	1.398	1.183	0.976	1.402	1.080

	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	Total.	Average Monthly.	Average Daily.
January......	21.163	75.181	11.732	22.602	53.774	16.366	49.170	48.898	35.150	14.322	29.657	851.900	37.039	1.195
February.....	58.019	24.851	6.721	20.249	25.217	23.374	61.898	85.630	16.012	25.116	14.077	772.701	33.596	1.189
March........	74.121	114.290	40.030	82.565	93.819	74.042	34.752	48.911	65.588	100.667	88.450	1 847.757	80.337	2.592
April.........	114.346	86.740	51.853	91.356	63.781	111.442	52.545	117.669	71.351	67.599	59.888	1 987.691	86.421	2.881
May.........	48.340	43.310	19.961	53.728	40.834	62.221	29.092	50.211	60.183	38.737	78.117	1 123.285	48.838	1.575
June.........	22.088	35.842	22.706	13.827	10.228	9.370	10.535	46.478	47.137	16.681	23.579	631.995	27.478	.916
July..........	3.894	4.147	14.076	4.677	3.418	9.013	65.448	20.765	13.189	8.473	10.865	460.414	20.018	.646
August.......	8.902	7.775	11.610	6.770	2.038	5.004	90.425	9.711	6.262	8.055	6.617	379.062	16.481	.532
September....	9.157	5.817	11.486	6.328	6.105	2.197	10.593	14.816	3.487	15.567	13.523	341.383	14.843	.495
October.......	5.557	4.067	65.275	22.470	22.865	3.679	9.596	11.660	30.216	8.538	10.283	520.061	22.611	.729
November....	5.797	13.551	43.897	30.528	19.947	7.181	43.508	24.300	16.918	15.633	38.895	627.012	27.261	.909
December.....	13.218	8.122	34.985	34.857	28.968	9.152	44.965	28.701	14.859	31.107	31.191	760.108	33.048	1.066
Total.........	384.602	423.693	334.332	389.957	370.994	333.041	502.527	507.750	380.353	350.496	405.142	10 303.370	37.331	
Average daily	1.054	1.161	0.916	1.065	1.016	0.912	1.377	1.387	1.042	0.960	1.110			1.227

TABLE 7.

MONTHLY YIELD OF THE MANHAN DRAINAGE AREA IN MILLION GALLONS PER SQUARE MILE. MONTHS IN ORDER OF DRYNESS, 1897–1919, INCLUSIVE.

Order of Dryness.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
1	9.838	8.940	3.967	2.357	5.526	11.893	17.026	15.589
2	17.477	10.694	6.124	4.617	8.970	15.575	19.452	18.512
3	19.996	20.773	7.427	5.251	9.427	17.309	28.965	19.198
4	29.976	31.287	8.937	5.659	15.735	22.885	35.303	19.804
5	33.651	37.087	11.300	11.220	19.409	27.422	42.091	19.916
6	36.206	39.352	13.016	14.632	23.773	30.858	45.624	21.931
7	48.868	42.706	13.991	29.476	25.893	36.275	45.650	25.451
8	59.251	47.097	20.242	29.791	30.469	51.197	48.431	29.019
9	62.604	57.376	25.605	47.154	68.637	56.264	58.163	53.967
10	71.322	68.798	45.558	59.537	81.938	69.759	81.556	63 556
11	75.626	75.718	50.634	86.321	123.050	72.593	82.601	82.160
12	141.361	117.074	147.789	116.188	195.499	133.004	125.716	142.516
Total	606.176	556.902	354.590	412.703	608.326	545.034	630.578	511.619
Average	1.661	1.526	0.971	1.131	1.667	1.493	1.728	1.398

Order of Dryness.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.
1	7.200	5.597	2.934	5.107	3.894	4.067	6.721	4.677
2	11.342	9.675	9.307	7.386	5.557	4.147	11.486	6.328
3	14.597	16.048	15.304	7.592	5.797	5.817	11.610	6.770
4	16.473	18.722	29.277	8.522	8.902	7.775	11.732	13.827
5	18.635	20.473	38.181	10.645	9.157	8.122	14.076	20.249
6	19.631	21.085	40.389	13.027	13.218	13.551	19.961	22.470
7	20.675	22.127	44.405	22.107	21.163	24.851	22.706	22.602
8	30.031	23.187	46.035	42.432	22.088	35.842	34.985	30.528
9	54.176	35.609	49.920	55.130	48.340	43.310	40.030	34.857
10	70.264	42.992	69.656	58.344	58.019	75.181	43.897	53.728
11	77.161	50.621	72.137	76.647	74.121	86.740	51.853	82.565
12	91.445	90.108	94.035	88.163	114.346	114.290	65.275	91.356
Total	431.630	356.244	511.580	395.102	384.802	423.693	334.332	389.957
Average daily	1 183	0.976	1.402	1.080	1.054	1.161	0.916	1.065

Order of Dryness.	1913.	1914.	1915.	1916.	1917.	1918.	1919	Average.
1	2.038	2.197	9.596	9.711	3.487	8.055	6.617	6.828
2	3.418	3.679	10.535	11.660	6.262	8.473	10.283	9.607
3	6.105	5.004	10.593	14.816	13.189	8.538	10.865	12.257
4	10.228	7.181	29.092	20.765	14.859	14.322	13.523	17.165
5	19.947	9.013	34.752	24.300	16.012	15.567	14.077	20.665
6	22.865	9.152	43.508	28.701	16.918	15.633	23.579	23.873
7	25.217	9.370	44.965	46.478	30.216	16.681	29.657	29.197
8	28.968	16.366	49.170	48.898	35.150	25.116	31.191	35.456
9	40.834	23.374	52.545	48.911	47.137	31.107	38.895	46.692
10	53.774	62.221	61.898	50.211	60.183	38.737	59.888	60.914
11	63.781	74.042	65.448	85.630	65.588	67.599	78.117	74.837
12	93.819	111.442	90.425	117.669	71.351	100.667	88.450	110.521
Total	370.994	333.041	502.527	507.750	380.353	350.496	405.142	447.973
Average daily	1.016	0.912	1.377	1.387	1.042	0.960	1.110	1.227

TABLE 8.

Monthly Yield of the Manhan Drainage Area in Million Gallons per Square Mile, Calendar Months in Order of Dryness, 1897–1919, Inclusive.

Order of Dryness.	January.	February.	March.	April.	May.	June.	July.
1	9.427	5.526	34.752	44.405	17.026	7.427	3.418
2	11.732	6.721	40.030	51.853	19.631	9.370	3.894
3	14.322	14.077	48.911	52.545	19.961	10.228	4.147
4	14.632	15.304	50.621	58.344	25.605	10.535	46.17
5	16.366	16.012	50.634	59.537	29.092	11.220	4.617
6	19.996	16.473	65.588	59.888	30.858	11.342	8.473
7	21.163	19.198	68.637	62.604	36.206	11.893	8.970
8	21.931	20.242	72.137	63.781	38.181	13.827	9.013
9	22.602	20,249	74.042	67.599	38.737	16.681	9.307
10	29.657	20.473	74.121	68.798	40.834	18.722	10.694
11	35.150	23.374	75.626	69.759	42.992	22.088	10.865
12	35.609	24.851	76.647	71.351	43.310	22.107	11.300
13	40.389	25.116	82.160	77.161	47.154	22.706	13.027
14	42.706	25.217	82.565	82.601	48.340	23.579	13.189
15	45.558	29.976	86.821	86.740	50.211	29.277	14.076
16	45.650	31.287	88.450	90.108	53.728	30.469	14.597
17	48.898	36.275	91.445	91.356	53.967	35.842	16.048
18	49.170	42.432	93.819	111.442	60.183	37.087	17.309
19	53.774	58.019	100.667	114.346	62.221	46.478	19.916
20	55.130	58.163	114.290	117.669	75.718	47.137	20.765
21	70.264	61.898	117.074	142.516	78.117	48.868	35.303
22	72.593	85.630	125.716	147.789	88.163	63.556	65.448
23	75.181	116.188	133.004	195.499	123.050	81.556	141.361
Total	851.900	772.701	1 847.757	1 987.691	123.285	631.995	460.414
Average	37.039	33.596	80.337	81.421	48.838	27.478	20.018
Average daily	1.195	1.192	2.592	2.881	1.575	0.916	0.646

Order of Dryness.	August.	September.	October.	November.	December.	Total.	Average
1	2.038	2.197	3.679	5.797	8.122	143.814	11.151
2	2.934	2.357	4.067	7.181	8.522	168.292	14.024
3	3.967	3.487	5.557	7.592	9.152	193.946	16.104
4	5.004	5.107	5.659	13.016	13.218	221.662	18.472
5	5.251	5.597	6.124	13.551	13.991	232.052	19.588
6	6.617	5.817	7.386	15.633	14.859	262.930	21.911
7	6.262	6.105	8.538	15.735	19.804	285.115	23.760
8	6.770	6.328	9.596	16.918	23.187	301.911	25.160
9	7.200	8.937	9.838	18.512	28.701	322.405	26.561
10	7.775	8.940	10.283	18.635	28.968	337.900	28.158
11	8.055	9.157	11.660	19.947	29.476	358.149	29.847
12	8.902	10.593	20.675	22.127	30.031	377.503	31.458
13	9.675	11.486	21.085	24.300	31.107	405.366	33.780
14	9.711	13.523	22.470	27.422	31.191	422.514	35.210
15	10.645	14.816	22.865	28.965	34.857	454.807	38.234
16	11.610	15.567	23.773	29.791	34.985	470.015	39.168
17	15.575	17.477	29.019	30.528	44.965	511.395	42.216
18	15.589	19.452	30.216	33.651	47.097	557.447	46.454
19	19.409	22.885	39.352	38.895	48.431	624.393	52.033
20	20.773	25.451	42.091	43.508	49.920	670.615	55.885
21	45.624	25.893	51.197	43.897	56.264	776.915	61.713
22	59.251	46.035	65.275	57.376	71.322	948.154	79.013
23	90.425	54.176	69.656	94.035	81.938	1 256.069	104.622
Total	379.062	341.383	520.061	627.012	760.108	10 303.370	
Average	1.6481	14.843	22.611	27.261	33.048		
Average daily	0.532	0.475	0.729	0.909	1.066		1.227

TABLE 9.

Manhan Drainage Area.

Table showing per cent. of rainfall collected; rainfall in inches received; inches of rainfall collected, and the average daily run-off, per square mile, for each year, 1897–1919, inclusive.

Year.	Per Cent. of Rainfall Collected.	Yearly Rainfall Received.	Inches Collected.	Average Daily Yield, Mils. of Gal. per Sq. Mile.
1897	58.71	59.415	34.88	1.661
1898	54.42	58.88	32.04	1.526
1899	53.23	38.29	20.38	.971
1900	50.53	47.025	23.76	1.131
1901	61.86	56.59	35.01	1.667
1902	56.48	55.53	31.42	1.493
1903	63.11	57.495	36.29	1.728
1904	60.44	48.71	29.44	1.398
1905	53.77	46.19	24.84	1.183
1906	45.31	45.24	20.50	.976
1907	56.99	51.66	29.44	1.402
1908	55.91	40.67	22.74	1.080
1909	46.96	47.125	22.13	1.054
1910	52.44	46.49	24.38	1.161
1911	41.99	45.79	19.23	.916
1912	48.43	46.315	22.43	1.065
1913	50.04	42.78	21.41	1.016
1914	48.64	39.38	19.15	.912
1915	54.85	52.70	29.41	1.377
1916	60.27	48.48	28.91	1.387
1917	51.72	42.32	21.89	1.042
1918	52.36	38.52	20.17	.960
1919	50.24	46.40	23.31	1.110
Average	53.79	47.91	25.77	1.227

Maximum percentage collected in 1903, 63 per cent.
Minimum percentage collected in 1911, 42 per cent.
Maximum inches collected in 1903, 36.29.
Minimum inches collected in 1914, 19.15.

TABLE 10.

TABLE SHOWING THE MEAN MONTHLY RAINFALL RECEIVED AND COLLECTED. PERCENTAGE OF RAINFALL COLLECTED AND YIELD IN GALLONS PER DAY, PER SQUARE MILE, ON THE MANHAN DRAINAGE AREA, 1897–1919, INCLUSIVE.

Month.	Mean Rainfall Received.	Mean Rainfall Collected.	Mean Percentage of Rainfall Collected.	Mean Yield in Gallons per Day per Square Mile.
January	3.71	2.13	57.49	1 195 000
February	3.94	1.93	49.01	1 189 000
March	4.17	4.62	110.93	2 592 000
April	4.04	4.97	123.01	2 881 000
May	4.03	2.81	70.42	1 575 000
June	3.82	1.58	40.93	916 000
July	4.30	1.15	26.80	646 000
August	4.58	0.95	20.72	532 000
September	4.12	0.85	20.73	495 000
October	3.92	1.30	33.22	729 000
November	3.32	1.57	47.18	909 000
December	3.96	1.90	47.97	1 066 000
Totals and averages	47.91	25.77	53.79	1 227 000

TABLE 11.

DRIEST MEAN CONSECUTIVE MONTHS IN YEAR ON BASIS OF MANHAN RUN-OFF.

Number of Consecutive Months.	Months.	Average Daily Run-off in Gallons for the Period.
1	September.	495 000
2	August — September.	513 000
3	July — September, inclusive.	558 000
4	July — October, inclusive.	601 000
5	July — November, inclusive.	662 000
6	June — November, inclusive.	701 000
7	June — December, inclusive.	756 000
8	May — December.	859 000
9	April — December.	1 080 000
10	March — December.	1 233 000
11	February — December.	1 200 000
12	January — December.	1 227 000

TABLE 12.

Comparison of the Mean Annual Rainfall and Run-off on the Manhan Drainage Area from 1897 to 1919, Inclusive, with That of the Nashua River Drainage Area for the Same Period.

	Manhan.	Nashua.	Percentage Manhan Greater than Nashua.
Mean annual rainfall, inches	47.91	44.87	6.7
Percentage rainfall collected	53.79	49.80	4.3
Inches of rainfall collected	25.77	22.345	15.4
Run-off lowest month — gallons daily	495 000	362 000	36.7
Run-off 2 lowest successive months	513 000	386 000	32.9
Run-off 3 lowest successive months	558 000	400 000	39.5
Run-off 4 lowest successive months	601 000	421 000	42.8
Run-off 5 lowest successive months	662 000	486 000	36.2
Run-off 6 lowest successive months	701 000	533 000	31.5
Run-off 7 lowest successive months	756 000	616 000	22.7
Run-off 8 lowest successive months	859 000	692 000	24.1
Run-off 9 lowest successive months	1 080 000	846 000	21.7
Run-off 10 lowest successive months	1 233 000	1 021 000	20.7
Run-off 11 lowest successive months	1 200 000	1 053 000	14.0
Run-off 12 lowest successive months	1 22 7000	1 063 000	15.4

TABLE 13.

Table showing the Storage Required to make Available Various Drafts in Gallons per Day per Square Mile of Watershed, allowing 6 Per Cent. for Water Surfaces on the Basis of Manhan Run-off and making no Correction for the Dry Days in the Months preceding and following the Critical Period.

Daily Draft.	Storage Required Gallons.	Period.
100 000	6 600 000	August — December, 1914.
200 000	17 300 000	June, 1914 — January, 1915.
300 000	32 600 000	June, 1914 — January, 1915.
400 000	54 100 000	June, 1914 — February, 1915.
500 000	75 500 000	May, 1914 — February, 1915.
600 000	96 900 000	May, 1914 — April, 1915.
700 000	117 900 000	May, 1914 — July, 1915.
800 000	151 100 000	June, 1910 — April, 1912.
900 000	198 400 000	June, 1910 — March, 1913.
1 000 000	248 600 000	June, 1910 — December, 1914.

TABLE 14.

Table showing the Run-off of the Manhan Drainage Area for Driest Consecutive Months.

Number of Consecutive Months.	Average Run-off in Gallons per Day per Square Mile.	Number of Consecutive Months.	Average Run-off in Gallons per Day per Square Mile.
1	66 000	13	534 000
2	88 000	14	523 000
3	118 000	15	513 000
4	148 000	16	553 000
5	177 000	17	646 000
6	197 000	18	691 000
7	213 000	19	692 000
8	259 000	20	692 000
9	358 000	21	714 000
10	453 000	22	805 000
11	519 000	23	786 000
12	541 000	24	821 000

The mean annual flow for the whole of the period of twenty-three years is 1 227 000 gal. per day per square mile, which is 15 4/10 per cent. greater than the mean flow of the Nashua River for the same period.

The maximum run-off in any one year was 1 728 000 gal. per day in 1903, 41 per cent. more than the mean, and the minimum run-off was 912 000 gal. in 1914, 26 per cent. less than the mean.

In fourteen of the twenty-three years the run-off was less than the mean, and in every one of these years the rainfall for the year was less than the mean rainfall for the period. In the remaining nine years of the series in which the run-off was greater than the mean, the rainfall in every year was in excess of the mean rainfall for the period. The mean percentage of rainfall collected on the Manhan was 53.79 per cent., which is 4 4/10 per cent. more than the percentage of rainfall collected on the Nashua.

The table of mean monthly flow shows that the collection of water distributed through the different months in the year varies considerably from the distribution of mean rainfall throughout the year.

August, which averages the highest month in the year, in rainfall received, averages the second lowest month in the quantity of water collected, and is the month in which the minimum run-off occurred. July, which is second highest month in rainfall received, is the third lowest in run-off.

July, August, and September, the three months in which the highest rainfall was received, are the three months in which the least water was collected.

In the order in which the run-off is distributed throughout the different months, the Manhan corresponds very closely to the Nashua. In the matter of consecutive months, it is exactly the same. On the Nashua,

however, for the winter months, December, January, February, and March, the percentage of rainfall collected and the run-off both slightly exceeded that on the Manhan for the same period.

For the balance of the year the Manhan is higher both in run-off and percentage of rainfall collected, the run-off of the six driest months exceeding the six driest on the Nashua by about 31 per cent.

The storage required to make available various drafts agrees very closely in the higher drafts with the storage as given by the Report of the Committee on Yields of Watersheds in September, 1914.

The storage required for the lower drafts has been increased by the low flows subsequent to the making of the report by the committee.

The maximum run-off in one month occurred in April, 1901, with an average daily flow of 6 517 000 gal. per day, per square mile, which was almost one hundred times the minimum monthly flow in August, 1913.

The maximum daily run-off was 39 205 000 gal. on February 13, 1900; and the maximum flood discharge was on the same day at the rate of 183 cu. ft. per second, per square mile.

The rainfall for this month was 10.28 in. and included 4 storms greater than 1 in., the rainfall on day of maximum flood being 3.05 in.

Management.

The department is operated under a commission of three members, who serve without salary, one of whom is elected each year by the Board of Aldermen for the term of three years.

The commissioners select the officers and employees of the department, levy the rates, and collect and disburse the funds of the department through their own treasury, which is separate and distinct from the city treasury.

They are also, with the mayor, the trustees of the sinking fund established for the payment of the water department debt at maturity by annual sums set aside from the yearly receipts.

The department is self-supporting; in only one instance was it ever granted an appropriation raised by general taxation, and that was in the early days before the department finances were well established, when $10 000 was granted.

In 1901 this loan, together with interest at 4 per cent. for the whole of the period, was returned to the city treasurer.

Rates.

The present rates, which were established in 1909, provide for the sale of water by both the fixtures and the meter measurement methods.

Dwelling-houses, stores, and tenement houses generally are rated by the fixture; while mills, office buildings, and apartment houses of the first class are under the metered service.

The annual fixture rates are as follows, viz.:

For each family	$3.00
For each bathtub	2.00
For additional bathtub	1.33
For closet	2.40
For additional closet	1.60
For garden hose (limited use)	2.40
For rotary hose	9.60
For automobile	1.60
For washing machine	1.60

For stores a charge from $4.00 to $9.60 is made, varying according to the character of the business. Other established rates, such as the charges for horses, neat cattle, etc., yield such little revenue they hardly need to be considered.

Bills for service under the fixture rate are rendered quarterly, and a discount of 10 per cent. is allowed for payment in advance.

Metered water is charged at the flat rate of $5\frac{2}{3}$ cents per thousand gallons, the bills being rendered monthly and 10 per cent. discount allowed for prompt payment. A minimum yearly charge of $5.00 per apartment is established for all apartment houses on the metered service.

Meters are owned, installed, and repaired by the department, and the annual rental for their use is: $\frac{5}{8}$-in., $2.00; $\frac{3}{4}$-in., $2.00; 1-in., $3.00; $1\frac{1}{2}$-in. $6.00; 2-in., $16.00; 3-in., $24.00; 4-in., $50.00, and 6-in., $60.00.

Assuming that the unaccounted for water was 30 per cent. of the total quantity passed by the master meters in 1919, the cost to the consumer of water sold by meter measurement was $5\frac{1}{4}$ cents per thousand gallons; the cost to the consumer of water sold by fixture rate was 11 8/10 cents per thousand gallons, and the average cost to all the consumers was 8 3/10 cents per one thousand gallons.

The total cost, or book value, of the department at the close of the last fiscal year was $1 969 892.

The bonded debt was $441 000, and the amount in the sinking fund to meet that portion of the debt financed on the sinking fund method was $193 207, making the net debt of the department $247 793, or $12\frac{1}{2}$ per cent. of the total cost, and the net cost of the plant to the water-takers $1 722 009.

The gross receipts, from all sources, for the year 1919 were $168 804.83, equal to 8 6/10 per cent. of the total cost.

It would seem that an accusation of profiteering would fall flat against any corporation whose total receipts in 1919 were only 8 6/10 per cent. of its total investment.

Taxes.

The largest item of department expense after salaries and wages is the one generally called "payment of taxes" to the city of Holyoke. The payment called "taxes" by a municipal department into the city treasury

is an unusual thing, this being, so far as is known to the writer, the only department where such payment is made under legislative enactment, and the various municipal departments are required to pay for water used and for fire hydrants, the same as to a private water company.

This law was enacted in 1901, and as its provisions are self-explanatory it may be of interest to read them in full.

Section 2:

"The said Board of Water Commissioners is hereby authorized and directed to pay over to the treasurer of the said city in each year, on or before the 1st of November, from its net earnings, a percentage upon the total cost of the construction of said water works, as estimated in the annual reports of the said commissioners, which shall be the same as the percentage of taxation established for city, county, and state taxes in the city of Holyoke in that year. The treasurer is hereby authorized and directed to collect the said sum and pay over the same to the commissioners of the sinking fund for the payment of municipal bonds. In case the net earnings do not equal the said percentage, the whole net earnings shall be paid over as aforesaid. The amount so paid or collected shall be used toward the payment of municipal bonds, other than water bonds."

Section 3:

"The Board of Water Commissioners is hereby authorized and directed to collect payment from all municipal departments of the city of Holyoke except the Fire Department, for the water used by them, at the same rate which is paid by other consumers."

Section 4:

"The Board of Water Commissioners is also hereby authorized and directed to collect from the Fire Department an annual rental, not exceeding eight dollars ($8.00), for each public hydrant. This rental shall include the cost of all water used by the Fire Department for fire or other purposes, including the cost of furnishing and maintaining hydrants."

The total of all payments made by the water department to the city treasurer under these provisions is $422 556.26, and the amount received by the water department from the other municipal departments is $215-863.28, making the net cash contribution the water-takers have made for the benefit of the general taxpayer, $206 692.98.

A summary of the leading features of the Holyoke Water Works shows that its percentage of debt is small and that its present development is sufficient for many years to come; that its drainage areas when fully developed will provide for a city about twice its present size; that its supply is obtained from sources where the danger of pollution is slight and held in reservoirs large enough to provide long storage, and that the supply is delivered under a satisfactory pressure to the water-takers at rates which compare favorably with those in any city in this country.

Discussion.

Mr. Robert E. Horton.* I regret that more members of the Society who are particularly interested in matters of rainfall and run-off were not here to listen to Mr. Lucey's paper. He has pointed out some valuable records, and I am sure that members of the Society will receive with appreciation the paper that he so carefully prepared and presented, in print. I am sure we shall all find a great deal of valuable material and a great many ways in which the matter may be put to useful purposes.

Thirty years ago, when the records of the Manhan River were started, there were not, as I remember, more than a half dozen records that were reliable and generally available throughout the whole United States, and we can readily see under those conditions how valuable such a record becomes to us. The only way that that condition can be overcome is by the accumulation of such records. I know from experience that the keeping, day in and day out, of records of rainfall is a monotonous and arduous task, and I feel that the water department of the city of Holyoke is entitled to a great amount of credit for the excellent manner in which they have kept their records, and I might add in regard to other matters mentioned in this paper that I am forced to the conclusion from what Mr. Lucey has said that they have a most excellent water department.

There is one statement that interested me, and that is, the matter of charging for the water used. It has for a long time seemed to me that it was an entirely just and equitable proposition for the school and other city departments to pay to the water department the actual cost, or at the original rate, or on some basis for the water that they use.

Although that has been discussed here and there, Holyoke seems to be the only place where it is actually done. I should like to be in a position where I could some time say in answer to a municipal question, " If you would only follow the excellent example of Holyoke, some of your troubles would be done away with, because a large portion of the expense is being saddled on to the water department, and if the city departments pay their portion you might have money to put into your sinking fund to help pay for the future when you need an additional source of supply " ; and it would seem to me that a great deal of good would come about as the result of such a procedure.

I wish to ask one or two questions: First, as to measuring rainfall in the wintertime. Second, as to obtaining information as to taking water measurements, — whether there is any difference in taking at higher elevations than at the lower levels.

Mr. Lucey. Mr. President, we have no way of knowing just what the rainfall is at the upper end. On one or two occasions during the period we got water which showed that a storm had taken place at the upper end of the watershed and was not recorded at the lower. The snowfall

* Consulting Engineer, Albany, N. Y.

was measured in the usual way. We take a number of small measurements, and don't allow the can to fill up and lack attention.

MR. HUGH MCLEAN.* The question of taxation in Holyoke was a problem that bothered us for many years. The tremendous use of water for lavatories and schools and engine houses continued to grow, in spite of the care of our inspectors. The waste was enormous and the consumption was very high. I have always thought that the equitable and just way is for a water department to compel municipalities and their different departments to pay into the water department's treasury for all the water they use, and in return that should be credited as we pay into the city treasury what the average tax might be if a private corporation owned the water department. That is equity and justice. That tends to place the sale of water as nearly as possible on the cost-of-water basis. It has been in our mind to attain as nearly as possible perfection, and to establish the cost of water is only to make the consumers pay for the cost, and all of those who consume the water should pay for what they consume.

I think it is just to make a charge for everything that is used in new extensions. For instance, a farming suburb may be bought by a promoter, and he splits the land up into building lots which immediately increases the value of that land, merely from the fact that the water department and the gas and electric departments put their money in, and he sells all those lots for an enormous profit. We thought it perfectly just on applications for extensions like that to make them bear fifty per cent.

* Water Commissioner, Holyoke, Mass.

PROGRESS REPORT OF COMMITTEE ON ASSESSMENTS FOR MAIN PIPE EXTENSIONS.

MR. CALEB SAVILLE, CHAIRMAN.

[*September 8, 1920.*]

We have sent out something like three or four hundred inquiries to various parts of the United States. I will not attempt to read the replies, but just to show that we have not been lax in looking up this matter, there are two closely written, typewritten pages from private water companies, from whom we received reports and tabulated eleven pages of the same, on municipal supplies of various kinds. Some of the features — the salient features of these four fifths that might be called "primary conditions" — I will read.

Assessments for Main Pipe Extensions.

1. Common Method. — Guarantee of some stated amount annually, say 10 per cent. of the cost.

2. Duluth Method. — Eight per cent. of first cost of a 6-in. pipe, charged annually against abutting property for fifteen years on basis of 5 per cent. interest and 3 per cent. sinking fund, with 25 per cent. discount if payment is made in one installment. Against this charge is credited one half the water revenue paid by occupant of premises; vacant land pays full 8 per cent.

3. Washington (D. C.) Sanitary Suburban Commission. — Levies a benefit charge on all property in district abutting on the water mains. This benefit charge is to be paid annually during the life of the bonds out of the proceeds of which the construction work was done. Any property owner may extinguish the annual benefit charge by paying in cash an amount which, put at interest, $3\frac{1}{2}$ per cent. annually, will yield an annuity equal to the annual assessment for the period for which the assessment is levied. The annual benefit charges become a first lien against the property on which they are assessed for a period of two years unless reduced to a charge according to law. The benefit charge is payable immediately upon being levied, with interest at 1 per cent. per month.

4. Pennsylvania Water Company Method (private company). — "Bonus Agreement." To pay interest, depreciation, and taxes on the cost of the extension and furnish water to consumer there must be an average return equivalent to 15 per cent. on the cost of the extension. The minimum rate by this company is $10 per year; $10 is 15 per cent. of

$66.67. On petition for extension, the entire cost is advanced by the petitioner and held by the water company without interest. Refund is made to original petitioners at the rate of $66.67 for each new consumer supplied by the extension.

5. Bristol, Conn. — This city, by amendment to the city charter passed by the General Assembly of 1915 and approved by the voters of Bristol, October 7, 1919, has the following authority for laying a lien against abutting property both for non-payment of water bills and for cost of water-pipe extension:

"All charges for water, including an amount guaranteed as an inducement to lay new street mains, with the cost of laying or replacing service pipes upon public or private property, shall be a lien upon the real estate where or for the benefit of which such charges are incurred. When the estimated income shall not amount to 10 per centum of the estimated cost of laying a water main on any highway or private way, the Board of Water Commissioners may assess against the real estate to be benefited by the laying of such a main the cost above the amount of which the income shall be 10 per centum and such assessment shall be a lien upon such real estate. At least five days' notice shall be given to the owner or owners of the real estate upon which the cost of such pipe mains may become a lien, of the proposed extension, and of when and where it will be acted upon by the said Board. When the owner of the property upon which an assessment has been paid shall connect with the water main, the assessment shall be refunded or as much thereof as the assured income shall be 10 per centum. The liens provided for in this section shall have the same legal status as the liens provided for in Section 26 of this charter, and shall not continue for a longer period than 60 days after invoice of the authorized charges has been rendered, unless, within said period, a certificate of such lien shall be lodged with the town clerk for record."

The only place where we found, so far, that the assessment is a lien upon property has been at Bristol, Conn., where there was an act passed by the legislature giving that authority.

That seems to be the logical method, and to appeal at first sight to people. "Why not make it a lien upon the property?" I should like to say in regard to that, that at one time I discussed the matter very considerably with Mr. Stearns, and I remember his saying at that time that theoretically it was good, but practically not to do it. There were certain practical conditions that in his experience he had found were not good. I stated that this was the only place we had found; I think there are some others, because it was called to my attention, not long ago, that the city of Chicago laid a water main, and the cost was made a lien upon the property. It was carried up to the courts and the courts decided against the payment, on the ground that the extension was not warranted by the development of the property. That, gentlemen, is as far as we have gone.

Discussion.

Mr. J. M. Diven.* I should like to ask the members of the committee if any consideration was taken of the size of the main, or if the assessment was made on some definite size; such as six or eight inch.

Mr. Saville. We found in many places that 6 in. seemed to be a nominal size. It seems proper that, rather than to assess the cost on the actual operation, it would be better to determine a general rate covering the average conditions, for one man might be so unfortunate as to live on a rocky hill, and his cost of installation might be two or three times as much as if he lived in a low country where the earth could be easily excavated.

Mr. Diven. The method that I have used for a private water company and a municipal plant for new developments only, is this: The owners of the property advance the money for laying the mains, this money to be returned to them when paying a fair return on the cost. I think we took about ten or twelve per cent. If the development failed, the city or water company was nothing out. The promoter had to stand the loss. The water company or the city did not have to put up money for speculation.

President Macksey. I would say on this line that in a small city where I was employed recently we were on the old original system where, if there were voters enough on the top of the hill far out in the country, we laid the water main. When the water department authorities grumbled at the cost thereof, and called attention to the fact that there would be no return, it was said: "A large pipe is not necessary. Put in a 1-in. All we want is a little water." And after it was decided to furnish water the question would come up: "Isn't Mr. So-and-So going to pay the same rate as the others?" "Surely he is"; and therefore he should have good service. That meant that he should have a larger pipe. Now, if you laid a 4-in. pipe, you would have very good service. If you are going to furnish water to a man at all, the least that you might do is to protect his house against fire, and also against the rapacity of the insurance agent, by putting a decent hydrant in front of his house. Sometimes officials in charge of the water department protested against being forced to go on in this way. But the mayor — a very practical and effective man — said, "You go ahead. I will make them sign an agreement that the rental shall be 10 per cent. on the cost of the installation."

In another small place where I was employed they have the 10 per cent. grading. If a man or a number of men want a water extension it will be given to them, but they have to sign an agreement that they will guarantee that the income will be 10 per cent. of the cost. They are helped out in this way, that the cost is based on a 6-in. pipe, and the department might decide as a matter of diplomatic policy to put in an 8-in. pipe. The

* Superintendent, Water Works, Troy, N. Y.

necessary fire protection is furnished and the town contributes twenty-seven dollars per year per hydrant. They have a formidable-looking document that binds his heirs and assigns forever, and it appears that some of the authorities of that town thought that they had a lien, and talked about having it filed in the courthouse in the office of record, but it was nothing but a personal agreement. It ran as far as his estate ran; but when some of these fly-by-night real estate men move out they will take their estate with them, except the real estate, and you have no claim on that. I believe with Mr. Saville that the lien on the property is the thing. Practically, it has its difficulties.

PRESENTATION DEXTER BRACKETT MEMORIAL MEDAL.

Past-President Wm. F. Sullivan. Mr. President and Members: The committee on award being unavoidably absent, it becomes my pleasing duty, on behalf of the Association, to present to the winner for this year the Dexter Brackett Memorial medal.

You all knew, or knew of, the late Dexter Brackett, who served so long and faithfully this Association, who did so much to build up the high character of the papers presented, who contributed so much to the Journal, whose service to this Association was ceaseless. When Dexter Brackett passed on, you are familiar with the steps the Association took to perpetuate his memory by preparing a suitable memorial. The committee appointed performed its work with entire satisfaction to the Association. This committee believed that the memorial should take the form of service to our organization. Every year since the Memorial Fund was raised, an award of a Dexter Brackett Memorial medal has been made to one of our members, who, in the opinion of the committee appointed to judge, has presented before a meeting of this Association the best paper for the year.

I agree with the remarks of the President that this prize is within the reach of pumping-station engineers. The first memorial medal was awarded to Caleb Mills Saville. His was a practical paper by an eminent engineer. Last year it was justly awarded to David A. Heffernan, a high-grade superintendent, for his intensely practical and valuable paper. This year the committee has awarded the medal to another worthy member. The conditions of award are so eminently fair that there is no reason why this medal may not rotate from one to the other classes of our membership, provided it is won fairly. This prize award is open to all, to the engineer, the superintendent, the registrar, to the sanitarian, to the chemist, the stationary engineer, to the fireman or any member who is eligible.

Gentlemen, it is now my pleasing duty on behalf of the Association, to hand over to the winner this medal. His paper shows that he worked long and arduously, that he has given much time and thought to the preparation of this prize treatise. I might add that this Association is fortunate to have in its membership men who can and will write and present high-grade technical and practical papers which may go into the permanent records of the Association. Such a paper Mr. Robert E. Horton has written and read to us. It gives me much pleasure to present to you, Mr. Horton, the Dexter Brackett Memorial medal. [*Applause.*]

Mr. Robert E. Horton. Mr. President and Members of the New England Water Works Association: I believe there is an old adage to the effect that if you can think of nothing to say, say nothing, If you will kindly pardon me and allow me to get my bearings for a moment, I will

do so by telling a story, after which I wish to say something a little more serious.

I am reminded just at this moment of a small boy whom I once knew, who was very greatly interested in mechanical matters, and it was his great desire to become a carpenter. So, on his fifth birthday his parents presented him with a hammer, a plane, and a saw. He received the tools, and looked at them and said nothing. And his parents said, "Well, Johnnie, what do you think of them?" And after a moment's hesitation he said, "I am so hammered and sawed and planed that I don't know what to say." That is how I feel now.

I regret that it was not my privilege to know Dexter Brackett personally, but I am happy to say that it has been my pleasure to know many older members of the Association, some of whom have passed over the great divide. It has been my pleasure to know men older and more experienced than I, and from them — these men of the New England Water Works Association — I received the early inspiration to study the subject of rainfall.

It is not necessary to say that rainfall is very important from the viewpoint of the water-works engineer, for it is the

> "Little drops of water and little flakes of snow,
> Fill up the reservoirs and make the rivers flow."

In reality, we know very little of the real nature of rain, and it has been a source of pleasure to me, as I think it has been to every one who has undertaken the study of the manifestations of nature, to observe nature and its operation at work.

One of the rewards of the study of the phenomena of nature is the enjoyment of doing the work, and I believe that no one ever does any work that is worth while unless he does enjoy it. I took up the study of rainfall at a time when I was a younger man than I am now. The enthusiasm of work is not so potent in middle life as it was in the earlier days, and something is often needed to arouse enthusiasm. It seems to me that is one of the results which the Dexter Brackett medal may accomplish, and has accomplished in my own case. It affords a stimulation to further effort, because the medal carries with it the implication that our fellow-men — men who are well qualified to know of these matters — appreciate the efforts that have been made.

And so, Gentlemen, I want to thank you from the fullness of my heart for this medal. In addition to a feeling of pride at the honor you have bestowed on me, I think I feel a sense of humility when I contemplate what the efforts of one person can accomplish in comparison with the magnitude of the works of nature which are about us everywhere. In this respect, I feel very much as the Llama in Kipling's "Kim," who says:

> "All Nature is one great miracle."

Gentlemen, I thank you. [*Applause.*]

PRESENTATION TO MR. WILLARD KENT, SECRETARY OF THE ASSOCIATION, 1899–1920.

The PRESIDENT. Members of the Association and Guests, Ladies and Gentlemen: Your program is just a little bit changed. We have moved from old quarters into new, driven here by the high cost of living, and I think you will agree with those whom I have consulted at the head of the board, that we have been driven into good luck. We have had as good if not a better lunch than we could have got elsewhere. We hope to find this place agreeable to all the members and to be able to gather here for some time to come.

We have a very good program to-day, and outside of the printed program we have one unusual number. We have many men sitting around our board to-day who are old members of the Association, and who have served it both as members and as officers very faithfully. Though we do not often mention their service we do not forget them, and when, after years of faithful and valuable service a man retires from office, we do not forget his work, we wish to record our appreciation of it. So, on this occasion, the Association has decided that it would note the withdrawal from the office of secretary, which he held so long and in which he did such capable and faithful work, of Mr. Willard Kent; that on this occasion we would commemorate his withdrawal, and the arrangements for the affair were placed in the hands of a committee, of which Mr. John Diven is chairman. He will explain to you just what they did, how they did it, and why it was done. [*Applause.*]

Mr. J. M. DIVEN. Ladies and Gentlemen: I suppose if I were to tell something about water-works secretaries possibly it would serve to tell Mr. Gifford some of the things he ought not to do, being rather an adept in having done the things that a secretary cannot do. Somebody has very aptly said that the principal duty of the secretary of an organization of this kind is to do all the things that are so disagreeable that nobody else wants to do them. Mr. Gifford seconds that motion already, because he has been at it a whole year and found out.

John H. Decker always claimed to be the original water-works secretary. He was the first secretary of the American Association. But Mr. Decker has passed beyond, and we will have to accord that honor to Mr. Coggeshall, who, you all remember, was the first secretary of this Association. Mr. Coggeshall served, in two different terms, twelve years as secretary, followed by Mr. Albert S. Glover, who served for three years, and was followed by Mr. Whitney. Mr. Whitney was followed by Mr. Kent, who has served twenty-one years. He is of age now.

You all attend these meetings, and if everything goes right it is right; if things go wrong it is the secretary's fault. If your lunch is not all right the secretary is to blame; if it is all right — well, it is all right, that is all. No credit to the secretary, of course. I think members very little realize the troubles and cares that the secretary of an organization of this kind has, especially as was the case with Mr. Kent, having other work to do and unable to devote his full time to it. I presume many midnight hours were devoted by him to this work.

Now, we do not want Mr. Kent to forget old times; so we wish him to have this little *timepiece* to remind him of old times, and remind him always of the time of the meetings, so that we will always see him. We do appreciate his work, though we say little about it. I wish also to present Mr. Kent with this little box filled with our appreciation of his work, with our honor for Mr. Kent, and our love for Brother Kent. [*Applause.*]

Mr. Willard Kent. Gentlemen, I thank you. As we grow older we make fewer new friends, and the gradual slipping away of many of the old ones from various causes is one of the unpleasant experiences of life. Those that hold fast are therefore all the more appreciated. At the present time, when the spirit of change is so manifest throughout the world, I trust that, so far as it may affect the welfare of this Association, it may be for your prosperity and future success. I regret that I have not at this time the command of language adequately to express my appreciation of your kind remembrance. [*Applause.*]